MECHANICAL ENGINEERING

OCTOBER 1944

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 66 — NUMBER 10

Contents for October, 1944

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York 18, N. Y. Cable address, "Dynamic," New York. Price 75 cents a copy, $6.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . .

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Volume 66
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MECHANICAL ENGINEERING

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1944

GEORGE A. STETSON, *Editor*

For Distinguished Service

DURING the summer Major General L. H. Campbell, Jr., Chief of Ordnance, notified The American Society of Mechanical Engineers that it had been honored with the Distinguished Service Award of the Ordnance Department. As reported on page 674 of the A.S.M.E. News Section of this issue, the certificate of the award was presented to R. M. Gates, President of the Society, at a small meeting held in Washington on September 6. The certificate is reproduced on the facing page. The sense of satisfaction and pride that all members of the A.S.M.E. feel in learning that they have earned this recognition by the Ordnance Department of their services is natural and understandable.

Most members are aware of the fact that the Society maintained close contact with the Ordnance Department, during the years between World Wars I and II, through its National Defense Committee, reorganized in recent years and renamed the War Production Committee. Aside from the frequent sessions at A.S.M.E. meetings sponsored by this Committee, the services of the Society to the Department have not been of a nature that could be widely publicized. With the entry of this nation into the war, and for some time immediately preceding this event, these services grew rapidly in number and in importance. Every member is conscious of the extent and importance of his own individual contributions to the nation at war, whether made personally or through the Society; and some future historian may assemble a complete story of the Society's services. But as Mr. Gates said in accepting the certificate of the award, the Society must now turn its eyes to the future. It is our responsibility, he said, to set an example to the younger men to do an even bigger and better job in the future in co-operation with the Ordnance Department.

Rebirth of a Profession

ALL engineers who have the welfare of their profession at heart will give close attention to the address of President R. E. Doherty, fellow A.S.M.E., to the S.P.E.E. which appeared on pages 602–604 of the September issue of MECHANICAL ENGINEERING under the title, "The Engineering Profession Tomorrow."

Dr. Doherty has made a clear and concise presentation of an old and vexing problem. Briefly summarized, his address begins with the statement that "the engineering profession tomorrow will be largely what engineering education today makes it....If the profession is to be brought to the level which America needs, and is to receive the recognition which it deserves, the educators must bring it there." Two lessons of the present war are drawn—one, that "engineers...were altogether unprepared either by interest or understanding to cope with the fundamental issues that...underlay the emerging global conflict," and the other, that "the engineering profession found itself near complete paralysis when there was need for unified action on matters of common concern in connection with the war effort." As a step in preparing engineering education for its task of assisting the engineering profession to "rise to a new level," the S.P.E.E. Committee on Engineering Education After the War," has prepared a report, published in MECHANICAL ENGINEERING, June, 1944, pages 403–412, the study of which Dr. Doherty urgently recommends.

Raising the old question, "What is the engineering profession?" Dr. Doherty comments on the confusion of thought on it which he attributes to (1) no clear distinction between an engineering graduate who is practicing engineering and one who has entered a field beyond those directly related to his engineering studies, and (2) the "no-man's land between professional and subprofessional activity." To clarify this confusion Dr. Doherty sets forth "a few simple criteria for a professional group." These are "(1) that its members shall have acquired an organized body of higher learning; (2) that they serve their clientele by the application of that learning; (3) that they control a system of professional education and strive continually for its improvement; (4) that they share a common purpose and method of service and a common code of conduct with respect to each other and to their clientele; and (5) that they serve their country by expert counsel in their field, by participating as civic leaders in community enterprises, and by forming intelligent judgments on political issues and then actively supporting them." To these five criteria he adds a sixth, in the form of the following definition of engineering: "Engineering is the art, based primarily upon training in mathematics and the physical sciences, of utilizing economically the forces and materials of nature for the benefit of mankind."

The confusion which arises from failure to distinguish between professional and subprofessional levels Dr. Doherty treats very briefly. The "organized body of higher learning" essential to the professional engineer "means educational progress at least up to the level of the baccalaureate degree," and "the engineer's work is characterized largely by rational processes, whereas subprofessional work is characterized largely by rule-of-thumb methods."

Dr. Doherty goes on to say that if we accept the "picture" as he outlines it, "we are in a position to indicate the primary requirements with respect to which any program in engineering education should be tested," and refers his readers to the report of the S.P.E.E. Com-

mittee on Engineering Education After the War. He then expresses the wish that "some wise providence might cleanse our souls when we sit as designers of educational programs;" suggests three criteria for defining the "essential body of technological learning underlying the branch of engineering concerned;" and stating that "intellectual power, not merely routine skills and memorized facts, is the primary end," he submits seven "components" of the method and power by which this end may be attained.

The final paragraph of Dr. Doherty's address indicates what steps are now in progress:

"The report of the Committee on Engineering Education After the War points the way in education and the co-operation of the E.C.P.D. and S.P.E.E. committees according to a definite plan approved by both bodies affords the means for developing professional interest and understanding. Moreover, the E.C.P.D. Committee on Canons of Ethics is, after years of patient study, struggling toward a formulation acceptable to the whole profession. So the profession is trying to be reborn. I hope that we, as engineering educators, shall accept the opportunity now before us to take the lead in professional education, and lay the foundation for a genuine engineering profession that must, sooner or later, inevitably come, and that would contribute significantly to a prosperous and secure America."

It is hoped that the foregoing summary may induce many readers to turn once more to Dr. Doherty's complete address and study it carefully as a basis for clear thinking on a vital question. Packed into three pages, Dr. Doherty's frank and clarifying exposition commands close attention. Although directed to engineering teachers, the address is nonetheless a call for action by engineering societies to clear up the confusions that exist, to work more relentlessly and open mindedly toward the building up of a true profession of professionally minded men, and to enlarge the scope of that essential characteristic of all professions, the spirit of service to the public. With such a survey of needs and goals and with groups already at work to assess the one and attain the other, the next few years should, if engineers individually and collectively put their minds to it, witness the rebirth of the engineering profession.

Ball, Cooley, and Trump

THE American Society of Mechanical Engineers lost by death during recent months three of its honorary members, E. Bruce Ball, Mortimer E. Cooley, and Edward Needles Trump.

E. Bruce Ball, managing director, Glenfield and Kennedy, Ltd., Kilmarnock, Scotland, who died suddenly on June 17, at the age of 71, was elected an honorary member of the A.S.M.E. in 1939, when he was serving as president of The Institution of Mechanical Engineers. His career was marked with high honors and rapid advancement, beginning with his education and apprenticeship and extending through active service with engineering firms in England, Italy, the Far East, and the reorganization, during World War I, of the works of D. Napier and Sons for the construction of aircraft engines. He became managing director, Glenfield and Kennedy, Ltd., in 1918, where his engineering talents, his ability as an administrator, and his vital human interests extended to welfare of his workers and the advancement of technical education. He became an honorary member of The Institution of Mechanical Engineers in 1943.

Mortimer E. Cooley, dean emeritus of engineering at the University of Michigan, who died on August 25, at the age of 89, became a member of the A.S.M.E. in 1884, served as president of the Society in 1919, and was elected to honorary membership in 1928.

A graduate of the U. S. Naval Academy in the Class of 1878 he served in the Mediterranean in 1879, along the Atlantic Coast in 1880, and in the Bureau of Steam Engineering in 1881 when he was sent to the University of Michigan to teach iron shipbuilding and mechanical engineering. Resigning from the Navy in 1885, he accepted a permanent position with the University and became dean of the College of Engineering in 1904 and dean of the College of Architecture in 1913, posts he held until his retirement in 1928. His professional engineering activities included distinguished work in the field of valuation.

Thousands of engineers who came under Dean Cooley's influence in their educational and professional careers held him in warm affection for his unusual human qualities. During the closing years of his life he wrote an autobiography in which the few persons who have read it in manuscript form found, mixed with facts and observations, a host of anecdotes, the telling of which was one of Cooley's greatest gifts.

Few stories about Dean Cooley are more typical of him than one of the most recent. Having had difficulty in getting salt mackerel for his Sunday morning breakfast he finally wrote to a fish dealer: "I am an old man, do not expect to live for ever, and hope you can supply me with enough salt mackeral to last me the rest of my life and let me walk up to the Pearly Gates with one or two good-sized pieces for St. Peter." In about 10 days a barrel of salt mackerel appeared addressed to St. Peter, in care of Mortimer E. Cooley.

Edward Needles Trump, specialist in alkali manufacture and consulting engineer, died on June 21, at the age of 86. Mr. Trump joined the A.S.M.E. as a junior member in 1880, the first year of the Society's existence. He served as vice-president in 1905–1907 and was elected an honorary member in 1943. A Quaker, born in Philadelphia and educated at Cornell, his early years were spent as a machinist's apprentice and assistant superintendent in a beet-sugar factory. In 1882 he became associated with the Solvay Process Company and the Semet Solvay Company, Syracuse, N. Y. He was barely thirty years of age when he was advanced to the position of chief engineer of that company. From 1893 to 1915 he served both companies as chief engineer and general manager, and from 1915 to 1930 as vice-president and consulting engineer. He held many patents on chemical machinery for the manufacture of soda and for by-product coke ovens; he designed one of the first rotary cement furnaces, a continuous centrifugal drier, and a machine for measuring crushed or pulverized materials. In his later years he continued designing machinery and plants and he gave much time to public service.

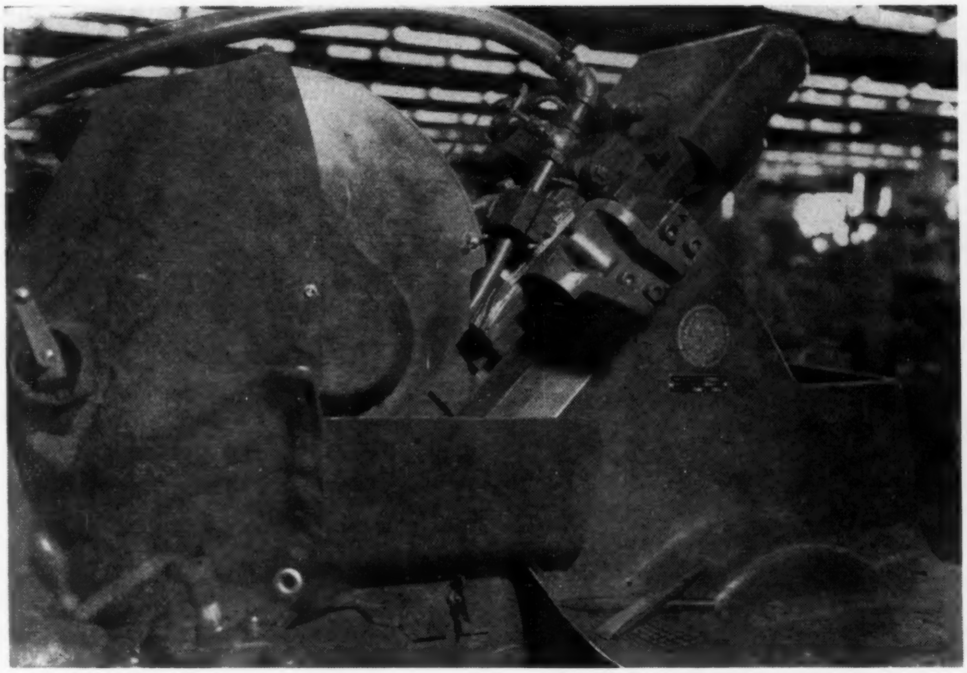

FIG. 1 THIS AUTOMATIC CHISEL GRINDER WAS DEVELOPED TO GIVE THE USER CONTROL OVER THE FORM AND FINISH OF FLAT CHISELS
(It is only necessary for the operator to place the chisel in the gage and press the starting button. When the cycle has been completed the chisel drops from the machine. The setting used at this yard will grind from 150 to 180 chisels per hr.)

TOOL CONTROL *Practiced at the* PUGET SOUND NAVY YARD

By W. E. AINSWORTH

MASTER MECHANIC, TOOL SHOP, PUGET SOUND NAVY YARD, BREMERTON, WASH.

EXTENSIVE employment of what is known as "centralized tool control" is proving a success at the Puget Sound Navy Yard. Unnecessary duplication of duties has been eliminated, tools are more readily available to all trades on demand, and government property is accorded the treatment it deserves. To accomplish all this, a service organization has been developed and is operated by personnel under the supervision of the shop superintendent.

CENTRALIZED TOOL CONTROL HAS MANY ADVANTAGES

The central tool shop is the custodian of all loose, hand, and portable power tools in the Industrial Department. It is held responsible for their upkeep, storage, issue, salvage, and accountability; when necessary it actually manufactures tools. This facilitates production, for production shops may concentrate their efforts upon the job at hand.

The advantages of centralized tool control are numerous. Among the most important is increased production through longer tool life. This is made possible by keeping records of performance and maintaining the equipment and personnel necessary to repair or duplicate any type tool. Where tool responsibility is divided and workmen grind their own tools, the efficiency of the tool will vary with the workman's skill in grinding. Moreover, as an average workman will grind only a few tools during his day's work, consideration of the amount of material he removes from the tool, the time it takes to grind it, or the performance obtained will not seem very important to him; his primary interest is to get his job done. On the other hand, if all these tools are delivered to one central point instead of being a minor part of a job, grinding becomes very important, and fixtures may be made or machines purchased that will give a uniform grind and provide the best possible tool performance in the least amount of time.

A very good example of how production may be increased with central tool control is afforded by a study of one of the Navy's most common tools, the pneumatic flat chisel. It is safe to say that there are more chisels used in ship construction and repair than any other type tool. Therefore, in increasing the efficiency of this tool, a great number of employees will be assisted in their task. In order to obtain the best results and maximum uniformity from this chisel, all factors in its manufacture must be under control, from the purchase of the steel or chisel blank to the finished product. In our opinion, all chisels forged from the same bar, heat-treated exactly the same and ground exactly the same, should prove to be fairly uniform. In our reconditioning of chisels by the thousands, daily, it was

Contributed by the Special Research Committee on Metal Cutting Data and Bibliography for presentation at the Annual Meeting, New York, N. Y., Nov. 27–Dec. 1, 1944, of The American Society of Mechanical Engineers.

NOTE: The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

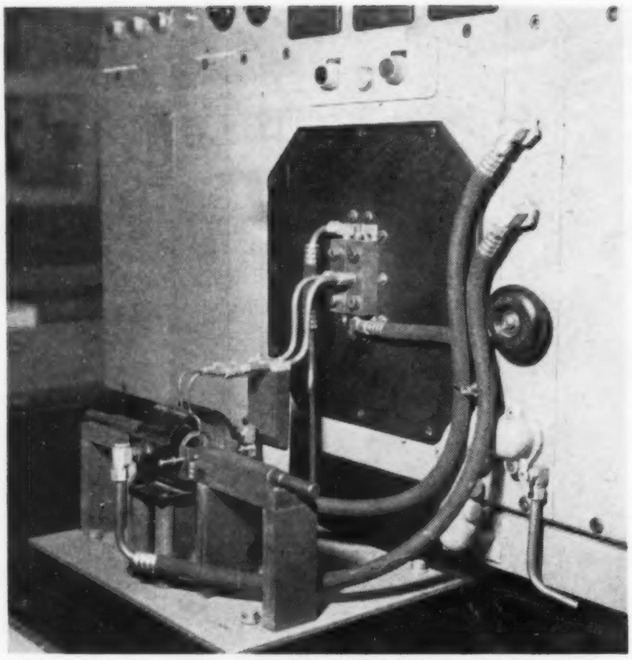

FIG. 2 AFTER PASSING THROUGH THE CHISEL GRINDER ILLUSTRATED IN FIG. 1, CHISELS ARE GIVEN A SURFACE-HARDENING TREATMENT ON THE CUTTING EDGE

(This is accomplished with an induction-hardening unit.)

found that the operators grinding these chisels freehand, regardless of how skillful they became, were turning out chisels that were not uniform. To overcome this difficulty, this activity purchased an automatic chisel grinder, Fig. 1. This machine is believed to be the only automatic chisel grinder in use, and although it is new in design and has only been in production a few months, the possibility of discontinuing hand-grinding of chisels completely looks very bright. After passing through this grinder, chisels are given a surface-hardening treatment of the cutting edge in an induction hardening machine, Fig. 2. This machine will handle approximately 300 chisels per hr. The results obtained from following the procedure outlined have shown a considerable increase in uniformity and cutting ability with chisels used for testing purposes. It is impossible, however, for the author to show the actual saving in the over-all production in this yard made possible by the chisel grinder and induction hardener.

To illustrate further the advantages of centralized tool control, a brief description of the process for reconditioning high-speed twist drills used at this yard follows:

RECONDITIONING HIGH-SPEED TWIST DRILLS

It was thought that the drill points produced on most standard drill grinders could be improved considerably. With this idea in mind, an exhaustive study was made to produce a drill grinder which would turn out a more efficient drill point. As a result, two grinders were developed which increased the number of holes between grinds by about 400 per cent (Figs. 3 and 4). The grinder shown in Fig. 3 has a capacity for drills $^1/_4$ to $^3/_4$ in. diam. It is hand-operated and grinds both lips at one setting.

The grinder, shown in Fig. 4, handles drills from $^3/_4$ to 3 in. diam. It is motor-driven and grinds both lips with one setting. In addition to the increase in the number of holes produced by drills ground on these grinders, drills are ground in much less time by inexperienced help. Drill points are checked for clearance as shown on the chart, Fig. 5. When drill points produced by these grinders become dull and are returned to the grinding room for reconditioning, the average amount of material removed is considerably less than normal. This is because of the decreased amount of relief, which wastes less material as the cutting edge wears away.

In the illustrations shown, of two very commonly used tools, the author wishes to bring to the reader's attention the improvements that may be made in reconditioning processes, after the establishment of a central grinding room has brought vast quantities of tools of a like nature to one point. At this point, small savings of time on individual tools become of collective importance, and research can be undertaken to improve the reconditioning process. The over-all result of such improvements is to reduce costs and increase production.

Other advantages are that fewer tools are idle, and inventory may be held at a minimum with tools being transferred from one toolroom to another, as required. The functions of the various groups in the central tool shop are more apparent by a study of each separate division.

TOOL-AND-DIE MAKING AND REPAIR

The tool-and-die shop, which includes a tool-design section wherein sketches of all special tools and fixtures are made, is equipped to manufacture gear hobs, taps, broaches, drop-forge

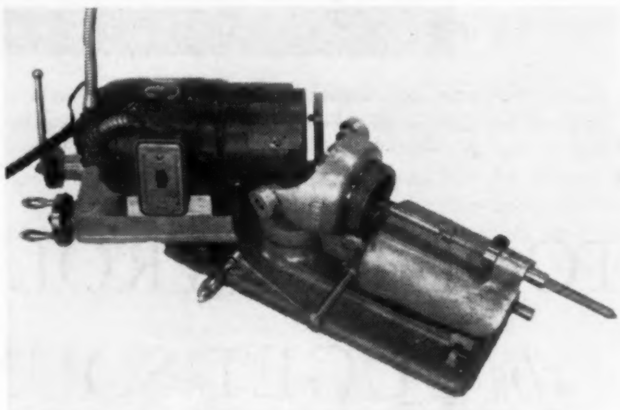

FIG. 3 SMALL DRILL GRINDER AS DEVELOPED FOR GRINDING $^1/_4$ TO $^3/_4$-IN-DIAM DRILLS

(Diamond dresser is shown on far side of grinding wheel. Feed stop is automatically set as wheel is dressed.)

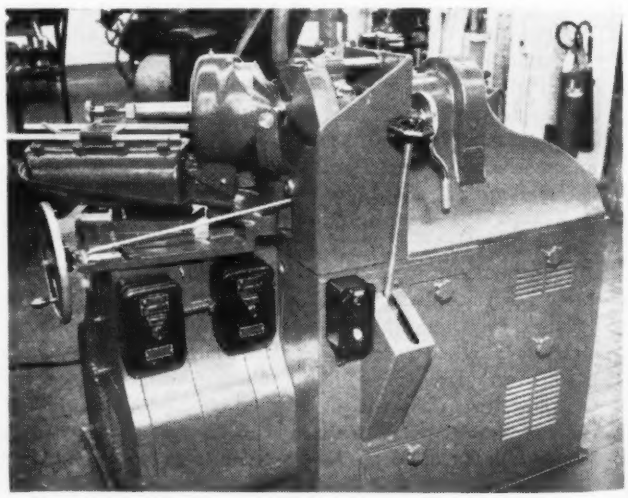

FIG. 4 LARGE DRILL GRINDER AS DEVELOPED AT THIS YARD FOR GRINDING $^3/_4$ TO 3-IN-DIAM DRILLS

(This machine is completely motor-driven and is equipped with adjustment for making the wheels oscillate on large drills. Diamond dresser is installed for use at any time machine is running. After chucking the drill, it is only necessary for the operator to feed it into grinding wheel until drill is sharpened.)

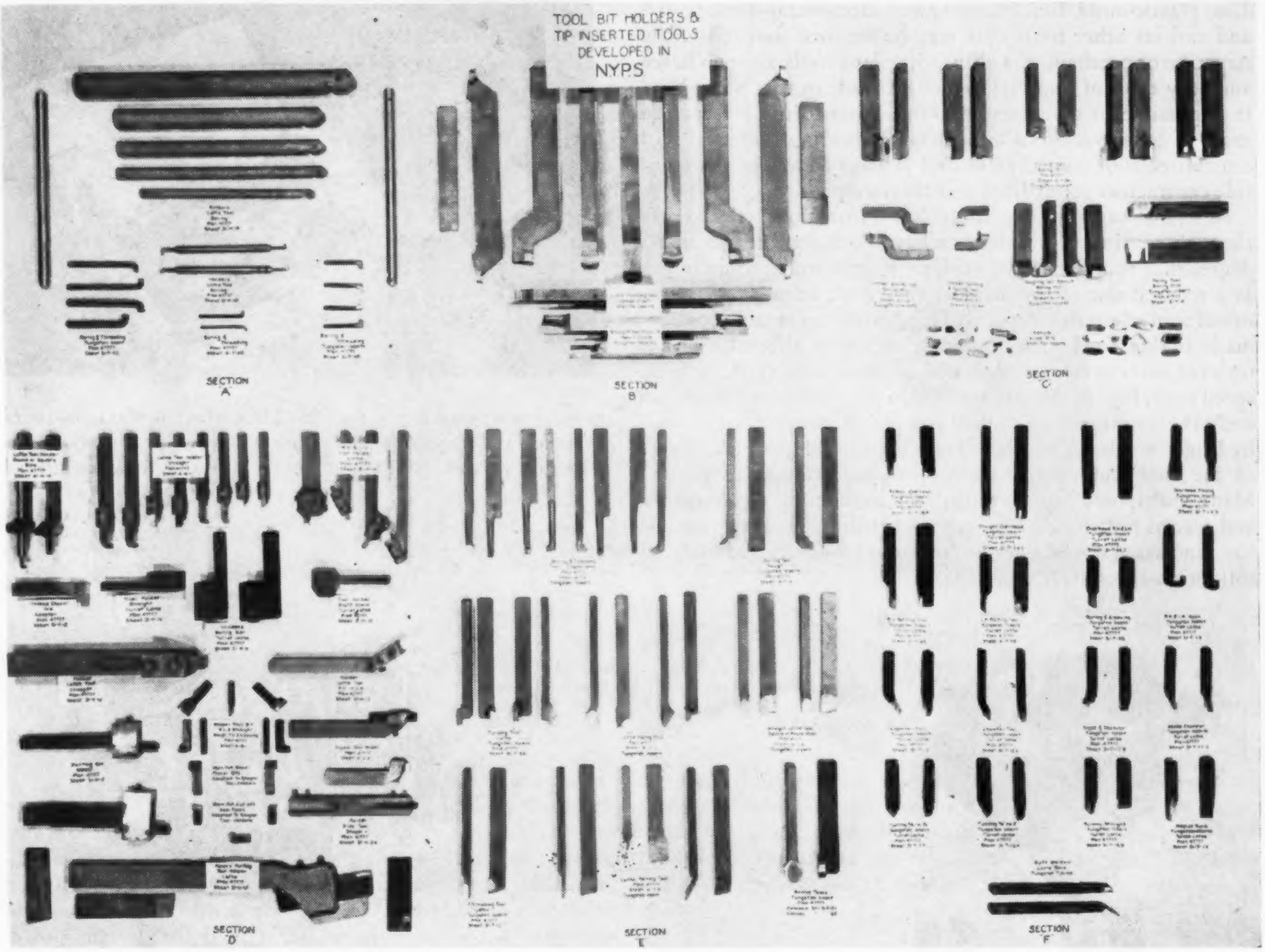

FIG. 6 TIPPED CUTTING TOOLS AND HOLDERS AS DEVELOPED AT THE PUGET SOUND NAVY YARD

(Cutting tools are constructed by welding high-speed-steel bits to low-carbon-steel shanks. Holders are constructed by milling square slot in shank and cap and welding the two sections together by the atomic-hydrogen method; this method is preferable to broaching square holes.)

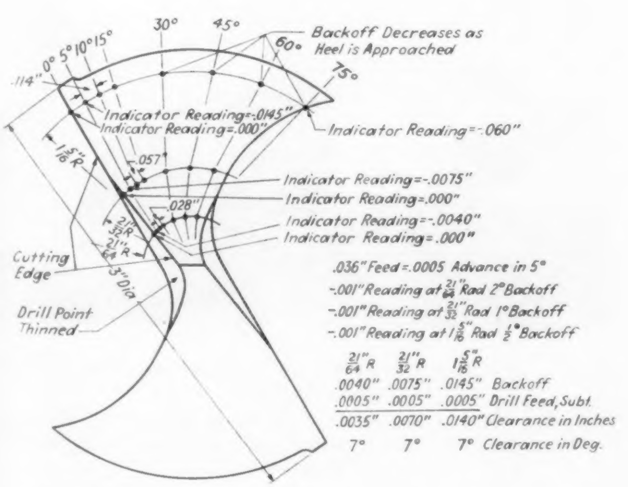

FIG. 5 CHART ILLUSTRATING MANNER IN WHICH TWIST DRILLS ARE CHECKED FOR AMOUNT OF RELIEF

(The surface behind the cutting edge is ground so that the relief angle increases from the periphery to the center, and the clearance angle is uniform from the periphery to the center. This method of grinding leaves a maximum amount of metal behind the cutting edge to carry away heat and reinforce the cutting edge, simultaneously crowns the chisel point so that the drill spins concentric when starting, and leaves the chisel point S-shaped, which forces the chips at the center of the hole into the flutes of the drill.)

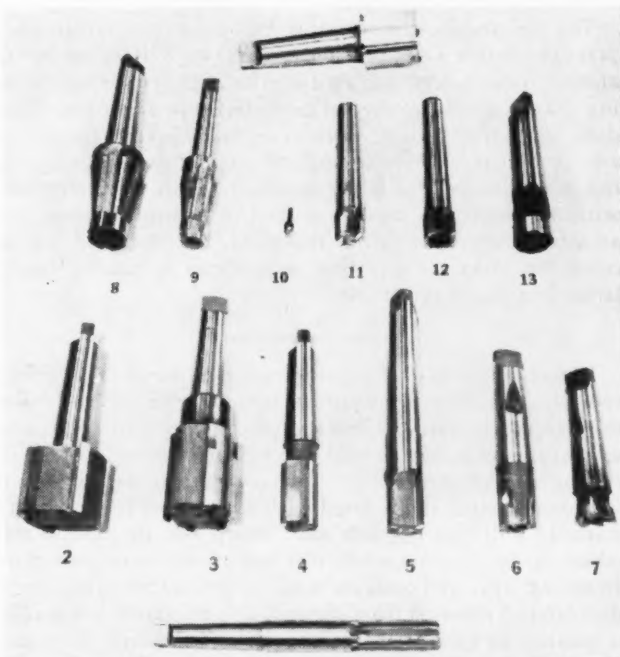

FIG. 7 MULTIPOINT TOOLS WITH INSERTED TIPS INCREASE PRODUCTION, SAVE CRITICAL MATERIAL, REDUCE MANUFACTURING COST

(The majority of tools have cast-type cutting bits brazed to the shank.)

dies, plastic-mold dies, blanking and sheet-metal-forming dies, and various other tools that may be required during the construction or overhaul of a ship. Standard tools are purchased, and only tools of a special nature are made in this Navy Yard. It is possible to give greater co-operation to the present program of conservation of high-tungsten-bearing tool steel with centralized tool control; and tool-salvage contracts with outside contractors are utilized to a maximum.

In many cases where tools have lost their effectiveness through continued grinding, or have been damaged to such a degree that they cannot be used, they are restored to usefulness at a reduced size of the original type tool, or made into some useful tool of another type. A large variety of cutting tools are made at this Yard with low-grade carbon or alloy shanks and inserted cutting tips or blades of carbides, cast type, or high-speed steel, Fig. 6. Inserts are held in place by several methods, such as clamping, steel-cement compound, brazing, or atomic-hydrogen welds. The method selected depends upon the design of the tool and various factors in connection with its use. Many multipoint cutting tools, such as reamers, countersinks, and special milling cutters, are made in this same manner and have increased the production far beyond that received from the solid high-speed-steel type, Fig. 7.

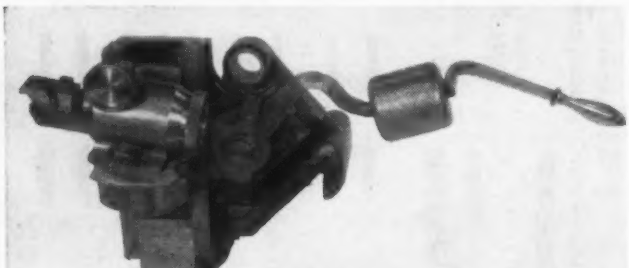

FIG. 8 FIXTURE FOR GRINDING THREADS ON GEOMETRIC-TYPE DIES

The tool-and-die department is responsible for tool salvage as practiced in this yard, and much might be written on salvage alone. Among items salvaged are the high-speed-steel threading chasers which are used in geometric-type die heads. These dies, when they become worn or damaged beyond further use, are reconditioned by removing the original threads and grinding new threads of a larger diameter. This is accomplished without annealing; dies are ground on a thread grinder with an attachment developed at this yard, Fig. 8. Dies that become too short for recutting are inserted as cutting tips on lathe- and planer-type tools.

TOOL GRINDING

Tools that are in need of grinding are delivered to the central tool shop in special containers from the various toolrooms throughout the yard. These special containers are constructed so that the tools may be held in position without injury to the cutting edges, Figs. 9 and 10. Each container is marked with its toolroom number and is fitted with a reversible cover which is marked "dull" on one side and "sharp" on the reverse side, which easily identifies where this box of tools is to go without attaching tags. All tools are machine-ground, thereby keeping the material removed from the tool at a minimum and making it possible to control the amount of clearance on the cutting edge. The clearance is measured by the indicator method rather than by the protractor or degree of clearance.

Special fixtures and attachments have been made in order that the operator grinding tools may produce the most efficient

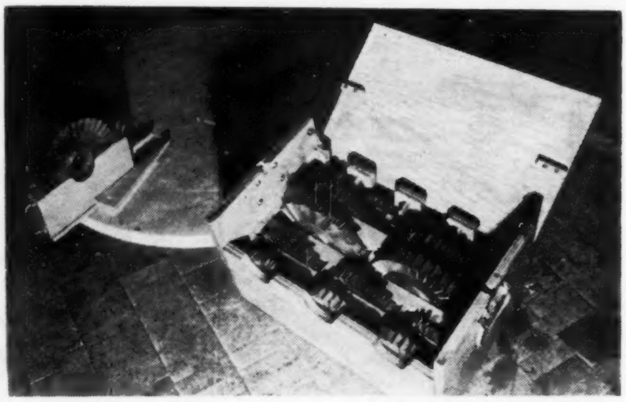

FIG. 9 IT IS IMPORTANT THAT STRADDLE MILLS BE WELL PROTECTED AS THERE ARE MANY CUTTING EDGES WHICH MAKE IT IMPOSSIBLE TO STORE ONE UPON ANOTHER WITHOUT DAMAGE TO SOME CUTTING EDGE

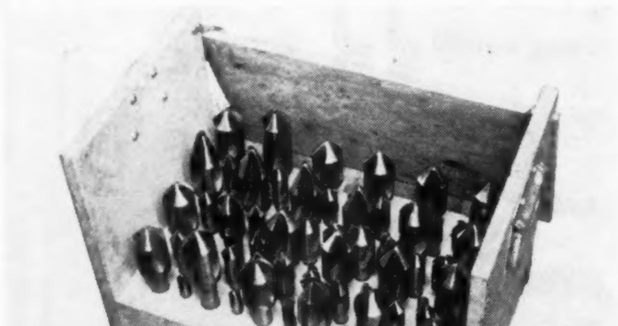

FIG. 10 SHIP COUNTERSINKS SHARPENED AND READY FOR SHIPMENT TO THE TOOLROOMS

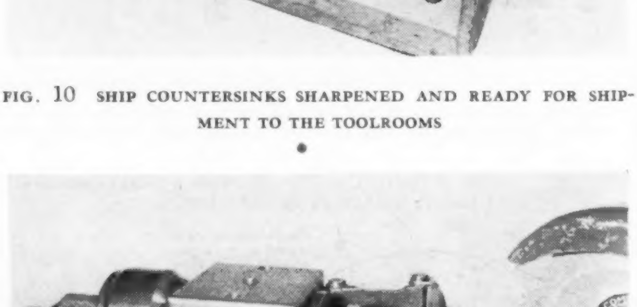

FIG. 11 FIXTURE FOR OBTAINING A SATISFACTORY GRIND ON SHIP COUNTERSINKS

(The proper relief is obtained through a cam-operated spindle which practice results in an efficient cutting tool, regardless of the operator's skill in grinding.)

grind on certain type tools regardless of his or her experience, Fig. 11.

The single-point grinding room, Fig. 12, is placed directly above the tool-issuing room where the bulk of lathe and planer tools are issued. A dumbwaiter serves as a means of transportation between the single-point grinding room and the tool-issuing room. The floor space of 20 ft wide × 80 ft long is considered ample for the maintenance of all types of single-point

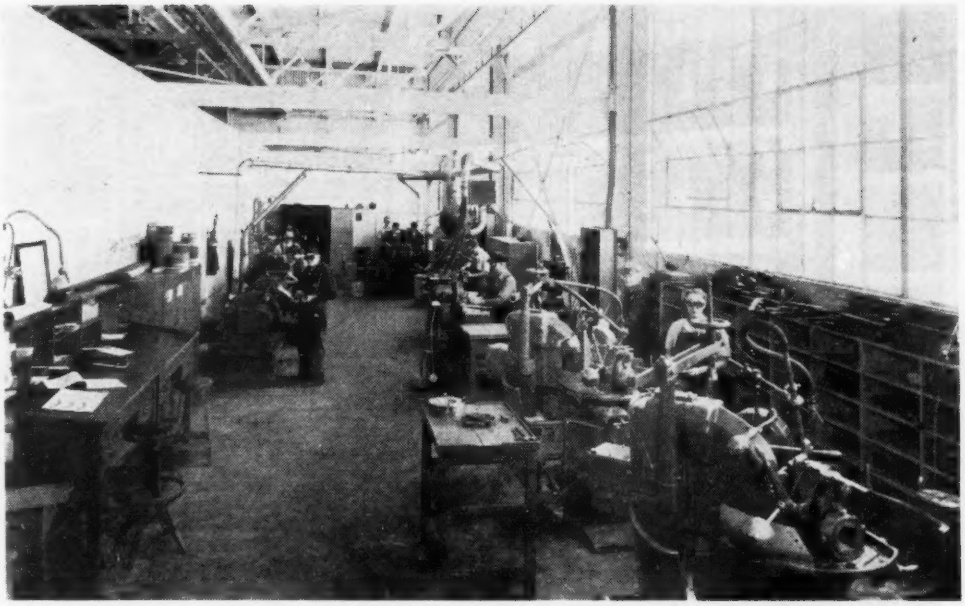

FIG. 12 VIEW OF SINGLE-POINT-TOOL GRINDING ROOM SHOWING WHERE ALL CARBIDE LATHE AND PLANER TOOLS ARE RECONDITIONED

(Standard high-speed tipped tools are also prepared at this point. Tools are delivered to the toolroom directly below this grinding room by a dumbwaiter.)

cutting tools used at this yard, and the modern grinding equipment which is installed makes it possible to duplicate any tool desired. Sketches and templates are available for the majority of standard tools.

The ultimate goal which this yard is attempting to reach is to have all single-point cutting tools ground by specialists at this central location and made available to mechanics when required. It is desired that tools which become dull be returned to the toolroom and exchanged for a sharp tool, rather than have the mechanic stop production while he grinds this tool freehand. The various cutting angles, which mean so much to the life of the tools and, consequently, to production, may be controlled more accurately by machine-grinding. Another advantage is that these tools may be run through the grinding machines in quantities, where setups will be held to the minimum.

It is impossible for even the most skilled mechanics to grind single-point tools to a uniform point, freehand, unless much time is spent and considerably more material ground from the tool than is necessary. To receive the greatest production from any tool, there is only one best set of angles or contour of point. This objective cannot be reached by having hundreds of mechanics grinding tools freehand. The ideal is reached by ascertaining the correct angles and point contour and then making all tools exactly the same by machine-grinding, removing the human element as much as possible, as this varies with each different workman and also with each workman's attentiveness to the job.

Operators have been carefully trained to grind tools correctly. Standard tools are used as much as possible, and special tools are generally made in sufficient numbers so that dull tools may be exchanged for sharp tools quickly, thereby reducing the down time on machines as much as possible.

To illustrate further the method of handling single-point tools of a special nature, this yard has an application man who analyzes special jobs and prepares a sketch of the desired tool which he then delivers to the person in charge of the grinding room. Here the tool is made according to the specifications. Upon the completion of the job in the shop, the tools are returned to the grinding room, reconditioned, and placed in storage pending the recurrence of the job. An accurate record of the performance of special tools is difficult to obtain, owing to the quantity of small jobs involved. However, a great reduction in tool consumption has been noted.

It is this yard's opinion that tool conservation and increased production at less cost is realized when single-point tools are handled as outlined.

(*Continued on page 637*)

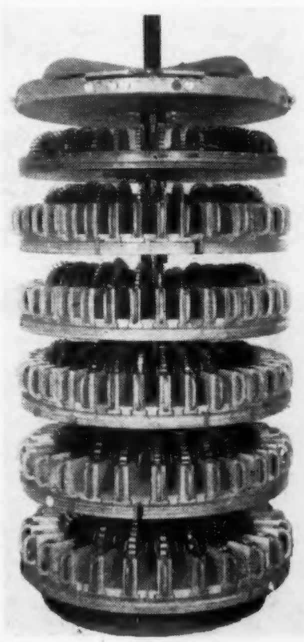

Fig. 13

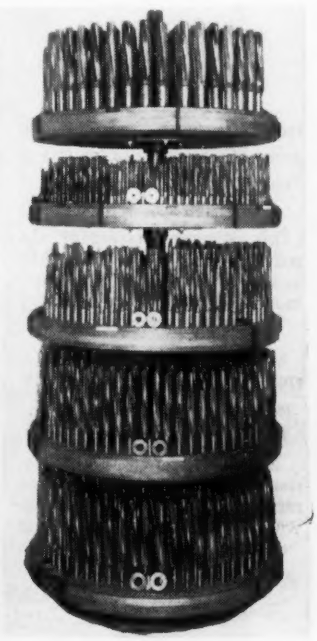

Fig. 14

FIG. 13 STRADDLE MILLS ARE PROTECTED UNTIL THE WORKMEN PLACE THEM ON THE MACHINE, THUS GIVING THE MECHANIC A KEEN CUTTING TOOL TO ACCOMPLISH HIS WORK

FIG. 14 METHOD OF STORING BRIDGE REAMERS IN TOOLROOM

(Note "go" and "no-go" ring gages for checking reamers each time they are placed in storage racks. Tools were assembled from various toolrooms in order that picture would show capacity of tool rack.)

FIG. 15 THE PROPER STORAGE OF CLAMPING BOLTS GREATLY ASSISTS THE MECHANIC IN ACCOMPLISHING HIS JOB, AS HE MAY OBTAIN THE SIZE HE REQUIRES IN GOOD OPERATING CONDITION

FIG. 16 TYPE OF TOOLBOX AND CONTENTS ISSUED TO A LATHE HAND WHEN HE REPORTS FOR WORK

(This is representative of the toolbox issued to all tradesmen as they contain the tools commonly used by the mechanic of that particular trade.)

FIG. 17 SAFETY OF WORKMEN IS THE OBJECTIVE AT THE PUGET SOUND NAVY YARD

(Clean and sterilized goggles, respirators, etc., are stored in racks as shown, for workmen whose work is of such a nature that they require protective clothing.)

Fig. 16

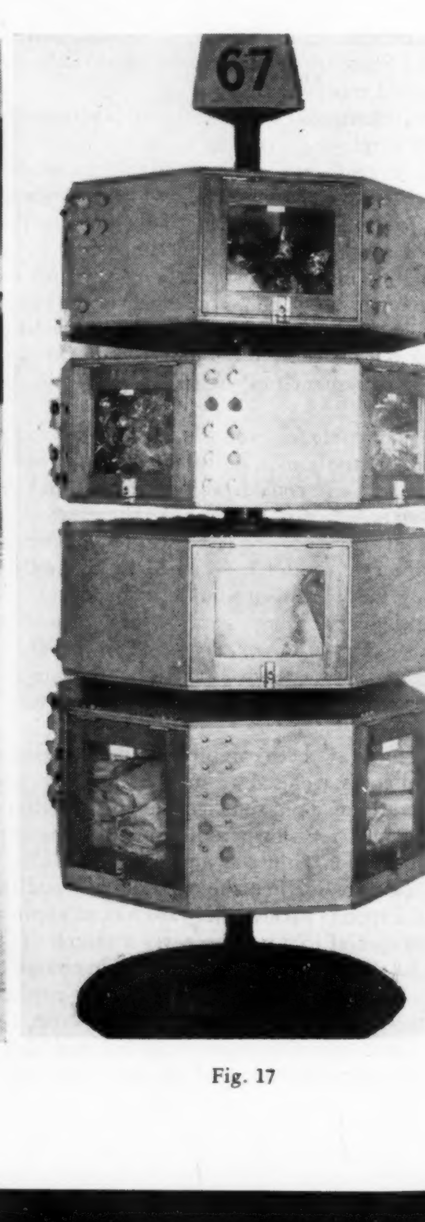

Fig. 17

STORAGE OF TOOLS IN TOOLROOMS

The method of storing tools in toolrooms is important, and considerable care is exercised in protecting the cutting edges. Racks are constructed so that the cutting edges of a tool in a rack cannot come in contact with another tool, Figs. 13, 14, and 15. It is not very profitable to arrive, after some effort, at the most efficient grind on cutting tools, and then place them in a tool bin where the cutting edges may become nicked and dull even before the tool has been placed in use. It is interesting to note that, as the storage of tools was improved, the personnel became more conscious of their value and exercised a great deal more care in handling them. The tool racks are rotor type in order that all tools may be in plain view and the floor space occupied kept to a minimum. It is necessary to custom-build most of the racks because of the various shapes and sizes of the numerous tools the yard is called upon to store.

INVENTORY

This department maintains a card-index system showing the amount of each size and type tool in the yard, and their location, including all grinding wheels used at this plant, with information concerning when to order a quantity sufficient for a 90-day supply. Duplication of tool purchases is eliminated through centralized tool control, as this group originates the tool request when the inventory of this material reaches the low limit, taking into consideration the time required for delivery.

Other advantages where tool requests are originated in one department are to standardize on different types of tools, keeping the spare parts for tools of assembled nature, such as portable power tools, torches, etc., to a minimum. Data may be compiled as to the performance of the various makes of tools, which is of value and assistance in making an intelligent recommendation as to the yard's preference. As material is received, it is stamped or otherwise marked with the government stamp, added to the yard-inventory cards, and placed in the various toolrooms where needed.

ISSUING TOOLS

Each new employee, when he reports for work, receives ten tool checks having the same number as his badge; journeymen and tradesmen in addition to the tool checks receive a trade toolbox, consisting of a standard set of tools common to their trade, Fig. 16. Workmen who are granted leave for more than 1 week return their tool checks and trade boxes to the toolroom nearest their work, where they receive a toolroom clearance slip with "Leave" stamped across the face. This toolroom clearance will not clear a workman's record so he may receive his final pay. An employee being discharged turns in all government property to the place from which it was issued, and receives a toolroom clearance slip with "Discharged" stamped across the face. This discharge clears the workman's record. Strict accountability is maintained by issuing all tools on tool checks. Steps are under way to install the double-check system whereby a workman receives a tool, and he also receives a square tool check which will identify the tool he has out; this will keep the workman informed at all times what tools are charged against his record.

MISCELLANEOUS DUTIES

All gear hobs when purchased or made are numbered and recorded in a hob book, copies of which are sent to the drafting rooms and shops concerned.

All micrometers, measuring tools, tachometers, etc. are checked for accuracy after each issue.

Goggles, respirators, welder hoods, etc., are sterilized after each issue, placed in good condition, packed in individual cellophane bags and stored in dustproof racks ready for reissue, Fig. 17. Pneumatic tools are cleaned daily, by washing free of rust, scale, etc., and oiled or packed with grease, according to the type of tool, Fig. 18. Grinding wheels are purchased and delivered through this shop, and maintenance men inspect machines daily and take care of minor repairs, dress wheels, and adjust guards.

FIG. 18 CLEANING AND OILING ROOM FOR WASHING AND GREASING PORTABLE PNEUMATIC TOOLS DAILY

A SUGGESTION SYSTEM THAT WORKS

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DURING the present wartime shortages of labor and materials, anything which conserves these commodities is a help to industry. A successful suggestion system definitely is such a help not only in saving time and scarce materials but also in raising employee morale through providing a direct channel of contact to the management and through providing possibilities for additional earnings. Furthermore, through lessened manufacturing costs, it improves the company's competitive position.

As a matter of background, the author's company manufactures communication equipment, largely for the independent telephone companies during peacetime, and entirely for the war effort during recent years. The present suggestion system has been in operation for 8 years and may be considered the successor to a former system (dormant for some years). When the present system was being designed, it was believed essential that all awards be paid in cash and that the system be kept simple to avoid its becoming top heavy and too great a burden to clerical and supervisory personnel.

As a measure of the current results of the system, the following figures are pertinent: Present total plant force is about 3800; we receive an average of 39 suggestions per year per 100 employees; of the suggestions received, 21 per cent are approved for an award; and the average award is $24.50. Payments of $19,750 of awards for 805 approved suggestions were made during the past $2^1/_2$ years. This has obviously been a worth-while activity.

The awards for approved suggestions vary from a minimum amount of $15 to a maximum of $500 for each suggestion. The amount of the award is determined as a sliding percentage of the net value to the company for the first year of operation under the suggested changed method. In the case of suggestions of small dollar value, it frequently happens that the award equals or even exceeds the first year's saving; and in this case the percentage would approximate 100 per cent of the saving to the company. Suggestions of larger dollar value are paid for at a diminishing percentage rate up to the maximum cash award mentioned of $500.

DETAILS OF THE AWARD SYSTEM

The full time of approximately $2^1/_2$ employees is required to handle the suggestion activities. The following will describe briefly the principal routines and procedures that make up these activities:

Suggestion Form. This form ($8^1/_2$ in. × 11 in.) allows the employee to sign his suggestion but, because he forwards it in a sealed envelope, and because of the secrecy surrounding its investigation, the suggestor's name is not divulged to his foreman. In this way the danger of supervisory jealousy is avoided. Blank suggestion forms and envelopes are available on each floor, and the sealed suggestions are forwarded to the Suggestion Department via regular plant mail.

Acknowledgment Form. An acknowledgment form, personally signed by the Suggestion Department head, is mailed to each suggestor within 24 hours of the receipt of the suggestion.

Investigation. Suggestions are investigated by Suggestion Department engineers. This largely amounts to co-ordinating the comments and recommendations of the interested groups: Tool superintendent regarding tool matters; personnel department regarding employee matters; laboratories regarding circuit changes; the safety engineer regarding safety suggestions, etc.

Approval. Suggestion approval requires agreement of the groups involved, plus agreement of a Suggestion Committee made up of four engineers from the Industrial Engineering Department, plus the approval of the general superintendent.

Notices of Acceptance or Rejection. These are mailed to each suggestor as quickly as possible. This usually is within about 3 weeks of receipt.

The published "Rules of the Suggestion System" state that each suggestion shall be the original idea of the suggestor himself; that minor suggestions such as correction of errors, small maintenance items, unimportant personnel matters shall not be eligible for awards but will be forwarded to the appropriate department for action; and that rejected suggestions not revived within 3 years shall become void.

RANGE OF SUGGESTIONS

Generally the suggestions received have to do with manufacturing processes or methods, with methods of tooling, with design of our component parts, with safety ideas, or with possible improvements in working conditions. A number of valuable suggestions have been made, relating to substitution of scarce or valuable materials, and also having to do with the use of obsolete parts, materials, or equipment.

We have found several effective methods of advertising or promoting the Suggestion System. The best of these is the cash awards. Whenever several sizable checks are given out, we can always expect an upswing in the volume of suggestions received. Each month bulletin-board notices are posted telling the number of approved suggestions and total amount of award money paid during the previous month. Originally our bulletins announcing awards mentioned the successful suggestor by name and also mentioned the amount of his award. We found by experience that the desirable spirit of rivalry which that method of announcement should foster was more than overbalanced by the jealousies and dislike on the part of the suggestor of such personal advertising. Our Labor-Management Committee has furnished helpful advertising for the Suggestion System both through man-to-man shop contacts and through letters "To all employees," over the signature of the chairman of the War Production Drive Committee.

Our general policy has been to be as liberal as possible in our decisions as to acceptance of suggestions; we have tried to "lean over backwards" to favor the suggestor; we have decided borderline cases in his favor, and we have always tried to devise ways to adopt a suggestion and pay its award rather than create an impression that we are rejecting suggestions to save payment of awards and then later putting those same ideas into effect. We are sincerely thankful to suggestors when they bring back a rejected suggestion for further discussion. We feel that our suggestion system is somewhat comparable to the small lunchroom on the corner; if the owner's business drops to nothing he fails; and possibly if one or two customers had told him that his coffee was not up to par, he could have corrected the situation and retained his trade. If dissatisfied suggestors tell us their grievances, allow us to reverse our rejection if we are wrong, or conversely, if we can satisfy the suggestor as to the justice of the rejection, we have "kept a customer."

BOILER-WATER TREATMENT

The New Science Versus the Old Art

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THE subject of boiler-water treatment is not new. Probably each reader has had something to do with treating water to be used in generating steam and what is recorded here is not likely to be entirely new to him. The technical literature, especially trade journals, publishes interpretations of some phase of the subject each month.

It is intended to review briefly what constituted the old art in boiler-water treatment, to discuss some of the significant things learned in the past 20 years, and finally to show how, slowly and gradually, with the accumulation of data by hundreds of chemists, the old art is being firmly established on a sound scientific basis.

WHEN WATER TREATMENT WAS AN ART

There can be little argument with the industrialist who in the past called the business of treating water an art. He was given plenty of reason to believe it to be so, as evidenced by the variety of compounds offered him as a cure-all for the ills, some real and some imaginary, he experienced in operating his boiler. Many an operator remembers the salesman who offered him the practically insoluble balls of some mysterious material which was guaranteed to stop scale formation and other boiler-water ailments. Then there were the hundreds of colored liquid compounds, some of which did a fair job in the case of some waters, but for which the operator paid a premium price for just water and a little soda ash. Associated with this sort of thing were the variety of "juices," cactus juice, hemp extract, and sugar-beet-pulp extract. And back further in years than these was the confident operator who kept out of trouble by throwing a shovelful of potato peelings in his boiler drum each day.

The boiler operator is not free from those who even now regard the treatment of water as an art, in that he continues to be offered correctives that are mysterious and secret. For example, consider "Scale-Buoy," for which the originators claimed so much that their enthusiasm knew practically no bounds. It was claimed that when water was treated with Scale-Buoy no furnace slag could adhere to the outside of the tubes. Moreover, boiler operators are offered electrolytic devices that are claimed to render the water non-scale-forming and noncorrosive; which automatically control alkalinity and actually cause adherent scale to dissolve.

It is not intended to argue against the use of some of these latter devices. It is doubtful if they will do all that is claimed for them, and they certainly will not do it under all conditions encountered. There is enough of fundamental truth in a few to make some of the claims seem reasonable but only under very limited conditions.

When was the change made from a system of art to one of science? Why was the treatment of water referred to as an art? There may be many reasons, but may not the real one involve the fact that the causes of the troubles encountered were not known and that the operator relied upon the elixirs and dopes that someone who claimed to know sold to him. There were enough instances of real or imagined success in the use of these compounds to cause them to be offered for a considerable period of time. As the changes that occurred to water and to the salts dissolved in it when heated under pressure to generate steam came to be better known, the treatment of boiler water passed from the realm of art to the realm of science. As knowledge of what actually constituted the water used in boilers increased, and as this was related to the changes observed to have occurred in the boiler, it became possible to apply sound chemical principles to the corrective treatment of water.

As the water chemist was learning more and more about industrial water, an important change was occurring within the industry that utilized water for steam-making purposes that also stimulated this change from an art to a science. Boiler-operating conditions were changing from those characterized by low pressures to those of high pressures; from 50 to 125 psi to 250, then 300, then 450, 600, 900, 1200, 1400, 1800, and now 2300 psi.

Water behaved differently at these pressures and the corresponding saturation temperatures than it did at the low pressures. Not only did the salts in the water behave differently but the reaction of the water on the confining metal, i.e., the boiler drums and the tubes, was different than before. It became necessary to understand these changes in order to operate boilers and steam generators safely.

TRANSITION FROM LOW TO HIGH PRESSURES

It is principally with these changes that this paper is concerned. It is intended to show in some detail why it was necessary to develop a science from the old art of treating water. The formation of scale was perhaps the first problem the boiler operator had to solve. Under low-pressure operation, scale could be easily controlled; the nature of the water, and by that is meant the kind and amount of salts dissolved in it, largely dictated what kind of treatment should be used. As pressures increased it was evident that some of the older methods of treatment became less effective. For example, under low-pressure operation, soda ash as such, or in any one of the many liquid compounds in which it was sold to the boiler operator, was a good scale preventive. Soda ash, however, had an undesirable habit of decomposing in such a way that the carbonate part of the salt, which is chemically known as sodium carbonate, would be liberated and escape as a gas (carbon dioxide), and the soda ash could not be depended upon to react with the scale-forming material, calcium and magnesium, as planned. The rate of decomposition was such that at operating pressures above 200 psi it was practically 100 per cent complete.

Dr. R. E. Hall, then with the Bureau of Mines, studied this reaction and after an extensive investigation pointed out the value of phosphates as scale-preventive chemicals that would not decompose at the higher pressures as did soda ash. Later, Dr. Hall developed a commercially new phosphate salt that has come to be used widely in water treating.

The effective and economical use of phosphate salts depended upon a greater knowledge of the chemistry involved than was the case with soda ash. There is only one soda ash, that is, it always has the same formula Na_2CO_3, two parts sodium combined with one part carbonate. In the case of phosphate salts, there are three principal varieties plus phosphoric acid, and these may be used effectively in combination, depending upon just what it is sought to accomplish.

Presented at a meeting of the Detroit Section of The American Society of Mechanical Engineers, Detroit, Mich., Feb. 1, 1944.

Consider for a moment this problem of scale prevention. To prevent scale, the objective is to produce a reaction between calcium or magnesium and the phosphate ion that results in the formation of a compound that remains dispersed in the water or settles out as a soft sludge. Those who have studied this reaction discovered that this would occur most effectively if the water exhibited certain minimum alkalinity characteristics. In other words, it was not enough just to have phosphate ions and calcium ions present to obtain the best results; other chemical conditions were necessary. Just as in the case of soda ash, the phosphate salts decomposed, i.e., hydrolized, and produced the alkalinity ion, OH. The extent to which the concentration of this OH ion developed, however, could be controlled by using the proper phosphate salt. If the most common, trisodium-phosphate, salt were used, the greatest amount of OH ion was formed; the disodium salt produced less; and if the monosodium phosphate or phosphoric acid were used, none was formed. From this it is understandable how, with the phosphate ion always present, it is possible to juggle the concentrations of the OH ion and maintain it at any predetermined value.

This does not represent the complete story of the chemistry of phosphate salts but it does serve to illustrate one of the complexities of this business of boiler-water treatment, and the necessity of knowing all of the factors involved.

CORROSION ATTACKS THE SCALE-FREE BOILER

In the course of events, it became possible to eliminate all scale from boilers. Operators who had been responsible for low-pressure boilers that had filled with scale, became surprised when boilers treated in this more enlightened manner, now practically scale-free, should develop another alarming trouble, namely, corrosion. As long as the boiler-metal surfaces had been covered with scale, corrosion was seldom encountered. With no scale on these surfaces the story was different. It soon became evident that the main cause of corrosion in boilers was air. It had been known for ages that air and water did not treat iron very well; but it was not until about 1920, that boiler operators came to know the damage that could be produced by small amounts of air or oxygen, especially on boiler-metal surfaces when no scale was present. From here on began the search for air leaks in feedwater systems and, when all of these had been found and apparently stopped, it became necessary to develop chemical treatments to counteract the effect of even smaller quantities of air that gained access to the systems when the operator was not looking.

These two problems were what might be called the basic water-treating problems common to all boilers and steam generators. As far as the average operator is concerned or perhaps more correctly, as far as he concerns himself with the business of making steam, they are practically solved. There is no longer any sound reason why scale and corrosion of the ordinary variety should occur in boilers, because they can be prevented.

In carrying this story farther, consider the case of large steam generators where generation of steam is carried on at pressures above 400 psi. Consider specifically those cases where steam is the primary product and where as much attention is paid to its manufacture as the average industrialist pays to some perhaps more tangible product, such as automobile parts, or war matériel. In this class fall the large electricity-producing plants, but not exclusively, because most large manufacturers now recognize the importance of devoting more attention, than formerly was the case, to the generation of steam.

TREATING WATER OUTSIDE THE BOILER

One of the first things that was learned about treating water for making steam was that, instead of forming a lot of sludge in a boiler in the treatment to prevent scale, sludge could be formed to a large extent outside the boiler and separated from the water which thereafter carried only nonscaling salts into the boiler. Processes doing just this have been offered to industry for a number of years and are typified by the lime-soda and zeolitic or base-exchange processes. These are strictly chemical in their nature.

Some of the large steam-producing companies contended that if steam were generated from pure water, and by that is meant just H_2O with no salts whatever dissolved in it, the most satisfactory conditions from the standpoint of scale and corrosion would obtain. To accomplish this, evaporators were installed, using steam extracted from the turbines as the heating medium, and large quantities of pure condensed water vapor were introduced directly into the feedwater systems or stored for use as required.

Neither of these two general classifications of feedwater or boiler-water treatment has proved to be entirely adequate under the present plant-operating conditions. They serve well to do the thing they were designed to do, i.e., remove all or most all of the scale-forming salts, but they could not take care of scale-forming salts that entered the boiler as raw-water leakage.

In general, the average boiler operator has given little thought to raw-water leakage into the feedwater system. As a consequence of inadequate external treatment, auxiliary treating chemicals have been added directly to the boiler drums in many instances. Moreover, since raw water contained air as well as scale-forming salts, it became necessary to install deaerators to remove the corrosion-producing elements which otherwise would enter the system.

Thus from the simple treatment of feedwater with soda ash, we see the art gradually attaining a scientific basis by the introduction of engineered external chemical treatment, evaporation, deaeration, and internal auxiliary chemical treatment.

ADVANCES IN BASE-EXCHANGE TREATMENTS

It may be said that, until 1942, this represented the progress in treatment of water for industrial purposes. It is true, of course, that changes were made in zeolitic systems. Carbonaceous zeolites were developed that made possible the elimination of a great deal of silica in the feedwater. Following the development of carbonaceous zeolites, was the perfection of the dual zeolitic process in which part of the raw water was passed through a salt-regenerated zeolite bed and part through an acid-regenerated bed, the so-called "Zeo Dur-Zeo Karb" process, that reduced materially the total dissolved solids content of the water and made possible better alkalinity control. Processes of this general type, that is, base-exchange processes, are being developed now that may with certain types of raw water remove all dissolved salts as effectively as by evaporation. It is also true that various auxiliary treating reagents as well as mechanical devices installed within boilers have been introduced to combat some of the difficulties that have accompanied the change from low- to high-pressure operation.

The important point is that, as problems occurred they were solved individually, or if they were not actually solved, they were considered as individual problems. Until very recently, no one had taken the trouble to correlate all of the many facts that the study of operating practices by hundreds of individual chemists had brought to light.

TWENTY YEARS' STUDY OF BOILER-WATER TREATMENT

Consider briefly some of the facts that the past 20 years of study of boiler water have developed:

Caustic Embrittlement. This has come to be viewed as one form of corrosion. It has taken the efforts of many investigators, notably, Partridge, Schroeder, and Straub, working to a large extent independently, to bring to light the fundamental reactions that promote it and that may be used to inhibit it. It has been found that caustic embrittlement begins as a surface phenomenon, i.e., a corrosion reaction that is selective in that

it attacks the grain boundaries of the metal affected. The most significant factors relating to its occurrence are chemical environment and physical environment. Chemically, the boiler water must be of such a character that, when concentrated from 500 to 1000 times above the concentration ordinarily existing in the boiler water, it will attack the grain boundaries of the metal. Physically, the critical concentration of the water must occur at a point where the metal is stressed beyond its elastic limit. In general, caustic embrittlement has occurred in riveted drums at points where, by leakage to the atmosphere, the alkaline salts, principally sodium hydroxide, can concentrate to the degree necessary to produce an intergranular surface attack.

Studies have shown that caustic embrittlement may be prevented by any one of three chemical procedures which are as follows:

1 Through the use of tannins, maintained in a certain minimum ratio to the concentration of hydroxide in the boiler water; quebracho has been used chiefly for this purpose. The minimum concentration is 20 per cent of the sodium-hydroxide concentration at operating pressures of 200 psi but increases to 40 per cent at pressures of around 600 psi.

2 To maintain a certain ratio (roughly 1 to 2) of the concentration of nitrate ions to hydroxide in the water.

3 To eliminate free hydroxide from the water.

Which of these should be applied in any specific case may depend upon other conditions of the normal water treatment employed. It may be a simple matter to add quebracho to a normally pure water and produce a boiler water that will not cause embrittlement. This material, however, causes all precipitated salts to become dispersed throughout the mass of boiler water and has been observed under certain conditions of steam generation to promote the adherence of the precipitated salts on boiler metal.

Nitrates have been found to be particularly effective in locomotives. These salts were first tried out in such equipment, which is probably the explanation for their extensive use in the railroad field. Although all cases of embrittlement have not been examined with this nitrate factor in mind a large number have been, and it now appears as a reasonable explanation that many boiler waters do not cause cracking because there are significant concentrations of nitrates in them.

The elimination of free hydroxide appears to be a direct and positive way to guard against caustic embrittlement. The question may well be asked, how can this be accomplished, in view of the statement that certain minimum alkalinities are necessary to prevent corrosion and also to promote the precipitation of calcium and magnesium as non-scale-forming salts.

Purcell and Whirl[1] of the Duquesne Light Company in Pittsburgh, have pointed out significantly that there is a very definite relationship between the alkalinity expressed as pH, which is a measure of the concentration of OH ions in the water, and the equilibrium between phosphate and sodium ions. Furthermore, if the pH is maintained with regard to that equilibrium, no matter to what extent the water concentrates and even if it evaporates to dryness, no free sodium hydroxide will exist. It will all react with phosphate to form either the di- or trisodium salt.

It is, of course, important to know whether the boiler water in question is likely to promote embrittlement if it is permitted to concentrate. One of the most important contributions of the investigators working under the auspices of the Joint Research Committee on Boiler Feedwater Studies has been the embrittlement detector. By means of this device, a typical boiler-metal specimen may be stressed beyond its elastic limit in contact with boiler water, progressively concentrating to dryness. If within a reasonable length of time, say 30 or 60 days, the specimen, upon removal and examination, gives evidence of cracks, the operator is warned that the water is embrittling, and he can take steps to correct it if he chooses. It does not indicate to the operator that his boilers will crack. The other conditions of stress and concentration through leakage at the point of stress must exist before cracking will occur.

Black Magnetic-Iron-Oxide Attack. Associated with this problem of embrittlement and corrosion in boilers is one brought about through overheating of boiler-tube metal that results in the formation of black magnetic-iron oxide. Because of the manner in which this problem sometimes presents itself, it has been thought of simply as a severe case of corrosion, and the cause has been sought in air leakage to the system. It truly is corrosion, of a type caused not primarily by oxygen associated with air entering the boiler but by reactions that probably involve the substance H_2O influenced by heat. It may also occur as a reaction between boiler steel and sodium-hydroxide solutions which concentrate at the metal surface within a mass of loosely adherent deposits of precipitated boiler-water salts which have accumulated at the point affected.

The results of such reactions have been discussed as a function of steam-binding by Hall and Partridge[2] and by Straub and Nelson.[3] Whatever the reaction, it results in relatively large patches of severe corrosion on the water surface of tubes. The metal is actually eaten away and in some instances the affected spot is partially or completely filled with black magnetic-iron oxide. Upon closer inspection, cracks in the metal are evident, and under the microscope, these appear intercrystalline in nature.

This sort of corrosion is not confined to any particular area of the tube surface in the boiler. It has been seen over large areas of a waterwall; it has been seen in floor tubes where the inner surface of the tube nearest the fire was reduced in thickness by one third; and it has occurred in straight, sloping, slag-screen tubes near the top of a combustion chamber. In one such instance, an elongated section of tube wall about $2^1/_2$ in. wide and 18 in. long was blown out of the tube as the result of the penetration of intercrystalline corrosion around the edge of what turned out to be the fragment.

Many questions may be asked about such occurrences. Why does such corrosion occur in only one or two of a group of practically identical boilers? If it occurs in one boiler why not in many? What are the governing conditions? What shall be done to prevent its recurrence? Can conditions of the water be corrected through chemistry to the end that such corrosion can be inhibited? It is possible to inhibit all forms of corrosion in boilers through chemistry, and a great deal of grief resulting from corrosion could be prevented if the elements conspiring to produce it would announce their intent soon enough. The difficulty is that each new case is sufficiently different from others that to understand all the factors requires practically a complete investigation each time.

A factor that should not be overlooked is a purely physical one, namely, circulation. We can safely say that if water and steam traveled through the maze of tubes that make up some of our more modern boilers in the manner the designer intended, there would be no corrosion of this character. The importance of good circulation, especially in high-pressure boilers, is recognized by boiler manufacturers, and troubles of the

[1] Protection Against Caustic Embrittlement by Coordinated Phosphate pH Control, by T. E. Purcell and S. F. Whirl, Trans. American Chemical Society, vol. 83, 1943, pp. 343–459.

[2] "Attack on Steel in High-Capacity Boilers as a Result of Overheating Due to Steam-Blanketing, by E. P. Partridge and R. E. Hall, Trans. A.S.M.E., vol. 61, 1939, p. 597.

[3] " Corrosion in Partially Dry Steam-Generating Tubes," by F. G. Straub and E. E. Nelson, Mechanical Engineering, vol. 61, 1939, pp. 199–202.

sort under discussion are actually rare, none having been reported in the past 2 years.

Corrosion of Steel by Pure Water. Before leaving this subject, it is important to mention the corrosion of steel by direct reaction with pure water at elevated temperatures. Consideration was given this subject by The Detroit Edison Company when the Trenton Channel Plant was designed. Investigations of the relative corrodability of alloy steels in pure steam at temperatures as high as 1200 F were begun in 1927. These studies continued through 1942, and from them the engineers of the company have been aided in the selection of metal for high-temperature steam service in the newer steam generators in its powerhouses. Results of this work have been published from time to time by the A.S.M.E.

PROBLEM OF CARRY-OVER

So far, this discussion has concerned certain aspects of the scale problem, and various types of corrosion. Another problem, controlled to some extent by chemical treatment of the water, that is of tremendous interest where the steam is used in turbines, but of somewhat lesser importance in those cases where the steam is used in other industrial processes, is that of carry-over. By carry-over is meant the contamination of steam with boiler water or the salts of boiler water. There are data to indicate that boiler-water salts, especially silica, may be vaporized as such and contaminate the steam independently of droplets of boiler water.

What harm can carry-over do? In the steam-generating industry, carry-over can result in scaling of superheater tubes with attendant lowering of the rate of heat transfer through those tubes. Often these tubes will burn due to scale deposits. It can result in the formation of adherent deposits on turbine blading, greatly reducing the capacity of the generator and often necessitating unscheduled outage of a turbogenerator for the purpose of cleaning the blades. In the case of industrial-process steam, carry-over can contaminate heat-transfer surfaces and pollute products in the manufacture of which the steam, as such, may be involved.

What constitutes significant carry-over? The value that the feedwater chemist works with are so small that it has become customary to express them in parts per million in order that he may work with tangible numbers. If steam is contaminated by 1 ppm of extraneous material, dissolved or otherwise (and that is only 0.0001 per cent), the steam purity is considered to be unsatisfactory. Steam as ordinarily produced in The Detroit Edison Company's plants contains less than one half of this amount. Since it is the practice to operate the Company's turbines for 3 years without opening them up, these small concentrations of solids can in that time amount to sizable quantities. For example, consider the utilization by one turbine of 200,000 lb per hr of steam carrying 1 ppm of impurities. In one 24-hr day 4.8 lb of solid matter would pass through its rotor, if it is lucky and no solid matter adheres. In a 50-week year, 1680 lb would pass through, and if the machine ran continuously for 3 such years which none of them actually does, but the figures are interesting, 5040 lb would have passed through the barrel of the turbine. That is nearly two and a half tons of dirt.

Carry-over can be of such a character that deposits resulting from it may be entirely water-soluble or they may be water-insoluble or both in various proportions. Fortunately, The Detroit Edison Company, as well as other companies using Great Lakes water and no sand filters, encounters extremely little water-insoluble turbine-blade deposits in its present operation. That sort of experience is not generally the case elsewhere, and, throughout the industry, the problem is actually one of major importance. What has been or is being done about it? That constitutes one of the most interesting problems in the history of feedwater or boiler-water treatment and hence, warrants a brief discussion.

Solving the Carry-Over Problem. The steam-generating industry, as well as companies engaged in the business of treating water, have carried on or have supported investigations designed to discover the fundamental principles of carry-over and of the formation of either water-insoluble or water-soluble adherent turbine-blade deposits. The boiler manufacturers have designed steam scrubbers and separators having as their objective the removal of all solids or water from the steam. Considerable success has been achieved by both agencies, especially by the boiler manufacturers; but in spite of it all, some carry-over still occurs and turbine-blade deposits continue to form.

Of all the variety of salts that are found in boiler water, the silicates have been found to be the greatest offenders. Furthermore, it is important to mention that silicates are bad scale formers in the boilers themselves. Toward the end that silica might be eliminated or greatly reduced in concentration in feedwater, various external treatments have been developed to remove it in an external system. Practically all of the major water-treating agencies have studied the problem and have developed satisfactory procedures whereby feedwater can be produced containing as low as 2 to 5 ppm of silica. Even these low concentrations are sufficiently high to cause silicate scales and adherent blade deposits in some cases, and especially under higher pressure operation. It appears that regardless of how low the concentration of silica can be made in feedwater, unless it is completely removed, it, like the chloride ion, can reach significant concentration in the boiler water. Since it seems that silica cannot be eliminated from the water, we should, as Dr. Hall suggests, "learn to live with it."

Acting upon his own suggestion, Dr. Hall, in a paper[4] dealing with the utilization of potassium salts instead of sodium salts as treating reagents, reviewed fundamental data on silicates available in the government's Geophysical Laboratories, and with his keen appreciation of the problems of water chemistry, has related those and additional data, assembled from other sources, to the silica problem that confronts the industry. In addition to getting a clearer understanding of the physicochemical properties of silicates in their relation to boiler-water treatment, he evolved the basis of what may come to be sound physicochemical relationships applying to the whole problem of feedwater or boiler-water conditioning in all its ramifications.

CONCLUSION

In presenting this subject, it has been sought to explain why feedwater treatment was called an art; to explain how as the physical environment of boiler water changed with the development of steam-generating equipment designed to operate at pressures as high as 2300 psi, and the corresponding saturation temperature and even higher supherheat temperature, the complexity of the problems of boiler-water usage increased; and to show how greater dependence upon the fundamental laws of chemistry was necessary to solve these problems that presented themselves unannounced one by one; and in recognizing the necessity of that dependence, the old art has gradually developed into a science.

What is believed to be the first truly scientific application of basic physicochemical data to this entire problem has been mentioned. Such an application has long been needed; it manifestly was possible, but required the abilities of a man well grounded in physical chemistry and with a practical understanding of the needs of industry in order to introduce it. Its development lies in the hands of the boiler-water chemists who seek to solve their own individual problems.

[4] "A New Approach to the Problem of Conditioning Water for Steam Generation," by R. E. Hall, Trans. A.S.M.E., vol. 66, 1944, pp. 457–488.

Effect of SHAPE *on the* FORMABILITY *of* DEEP-DRAWN *Sheet-Metal* PARTS

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INTRODUCTION

THE great demand for metal aircraft has made it imperative, figuratively speaking, to streamline the design and production of sheet-metal parts. In order to guide part and die design intelligently, it is necessary to know the limitations of the material of construction and the forming methods. As a result, many studies both under private and government auspices have been directed at various phases of sheet-metal-part production. Basic principles of approach to the analysis of forming problems have been presented (1);[2] forming operations have been classified into basic operation as bending, stretching, and drawing (1, 2); and parts have been classified into characteristic groups (2, 3, 4). Formability tests and forming criteria have been suggested (1, 2, 5) and applied in practice. Technical articles have also appeared on stretch-forming (6), bending (7), and drawing (8, 9, 10, 11).

Typical aircraft parts formed by drawing are air-, oil-, and gas-tank shells, window frames, junction boxes, instrument covers, ducts, and airscoops. Brackets and corner seals and numerous other parts are also frequently formed by drawing.

To the designer it is essential to be able to predict from the design dimensions whether a part can be made in one, two, or more operations. Thus it is important to establish the maximum depth to which deeply recessed type parts may be drawn. From the standpoint of economy it is essential to design parts so that they may be formed in a single operation wherever possible.

It is the purpose of this paper to present experimentally determined results of the effect of size and shape on the limits for single-operation deep-drawn parts. The important elements that must be considered in determining the drawing limits are the over-all dimensions of the base of the part; the size of corner radii; the shape of the part whether round, square, rectangular, or irregular; and the thickness of the material. Punch nose radii and draw radii must also be considered in order to obtain optimum results.

DESCRIPTION OF DRAW-FORMING

Drawing is generally accomplished with a die consisting of three elements (see Fig. 1), namely, punch, die with draw ring, and hold-down pad. The blank is placed on the draw ring over the die opening. In operation, the hold-down pad descends onto the blank and supports it against wrinkling while the punch draws the blank into the die cavity. The metal moves radially inward on the draw ring and over the draw radius into place in the side of the part.

The radial inward movement is resisted by circumferential stresses in the material of the blank. The drawing force to overcome the resistance of the blank is supplied by the punch and results in a radial tensile stress in the blank. Thus the blank is subjected to combined radial tension and circumferential compression. This combination of stress makes possible large deformations and characterizes draw-forming. For a more detailed discussion of the mechanics of drawing, see references (1) and (8).

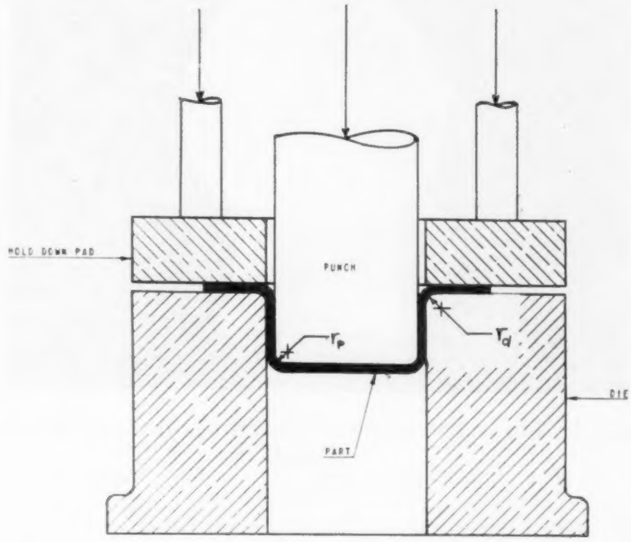

FIG. 1 TYPICAL DRAW-DIE ARRANGEMENT

If either the blank size or the hold-down pressure is excessive, the blank fails to draw, usually by tearing at the tangent point to the punch nose radius (see Fig. 1). In some cases, the failure occurs in other regions such as the lower tangent point to the draw radius.

EXPERIMENTAL PROCEDURE

General. Deep-drawing limits were determined by forming parts using the maximum-size blanks that did not produce failures, and measuring the depths of the resulting parts. The depths were used as a measure of the forming limits. Generally speaking, the blank shape used was the one that gave optimum results. For round and square parts, a round blank was found to give the maximum depths (see Fig. 2). For other shapes, the blanks used varied more or less from the round.

The maximum depth of a part h, that may be obtained by drawing, depends principally upon the length dimension d, the vertical corner radius r, the thickness of material t, the punch nose radius, r_p, and the draw radius r_d. Fig. 3 illustrates a typical square part. The round part may be considered a special case of the square part where the width of the flat side is zero. The experimental determination of the effect of the various dimensions was systematized by using the dimensionless ratios $\frac{h}{d}$, $\frac{r}{d}$, $\frac{t}{d}$, $\frac{r_d}{t}$, and $\frac{r_p}{t}$. The experimental work was generally arranged so that only one of these ratios was varied at a time. One of these ratios may be considered as the dependent variable and all the rest as independent variables. The ratio $\frac{h}{d}$ is here

[1] Member, A.S.M.E.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Presented at a Meeting of the Aviation Division of The American Society of Mechanical Engineers, University of California, Los Angeles, Calif., June 5–9, 1944.

FIG. 2 COMPARISON OF DEPTHS OF PARTS DRAWN FROM VARIOUS BLANK SHAPES

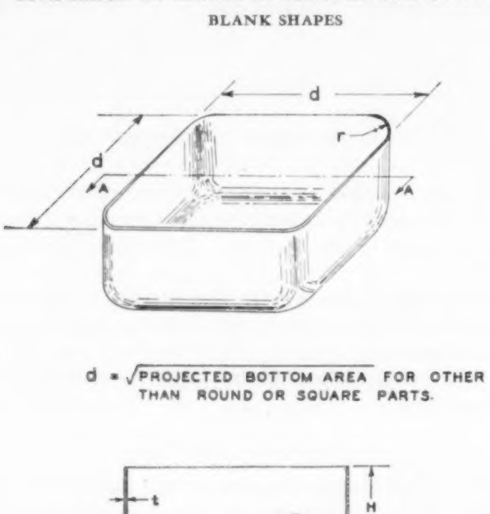

FIG. 3 BASIC DIMENSIONS OF DRAWN BOX-TYPE PART

considered the dependent variable and was used as a criterion of the formability and depth.

Practical considerations do not permit the use of arbitrary values for r_p and r_d. By a preliminary investigation it was established that values of $\frac{r_p}{t}$ and $\frac{r_d}{t}$ between 6 and 8 are very nearly optimum and consistent with good practice. Using values of $\frac{r_p}{t}$ and $\frac{r_d}{t}$ approximately equal to 6, the following were investigated:

1 The effect of t on h, holding r and d constant.
2 The effect of t and r on h, holding d constant.
3 The effect of d on h, holding r constant.
4 The effect of r on h, holding d constant.
5 The effect of size and shape.
6 The effect of irregular shaped base.

Presses and Dies Used. The experimental parts were formed in draw dies on double-acting hydropresses. The presses used were a 125-ton double-acting production press and a 300-ton double-acting laboratory press. These two presses were used at various times and for various forming tests so that the peculiarities of one press or the skill of certain operators would not influence the results. The dies used were the conventional bottomless type with punch, hold-down pad, and die. Kirksite was used for all large dies and steel was used for the smaller dies. In order to facilitate the setting up, all the small dies were made in the form of plates to fit a die plate holder (see Fig. 4). Clearances of metal thickness plus 10 per cent were used, except in the corners of square and rectangular parts where greater clearances were allowed. The relief in the corners was obtained by making the vertical corner radius in the die the same as the corner radius on the punch. It has been determined that this procedure greatly increases the depth to which a box-type part may be formed. Punch and draw radii on all the dies were approximately 6 times the metal thickness.

The lubricant used in all of the forming tests was X-49 drawing compound which was selected because it is the one used at Lockheed at the present time.

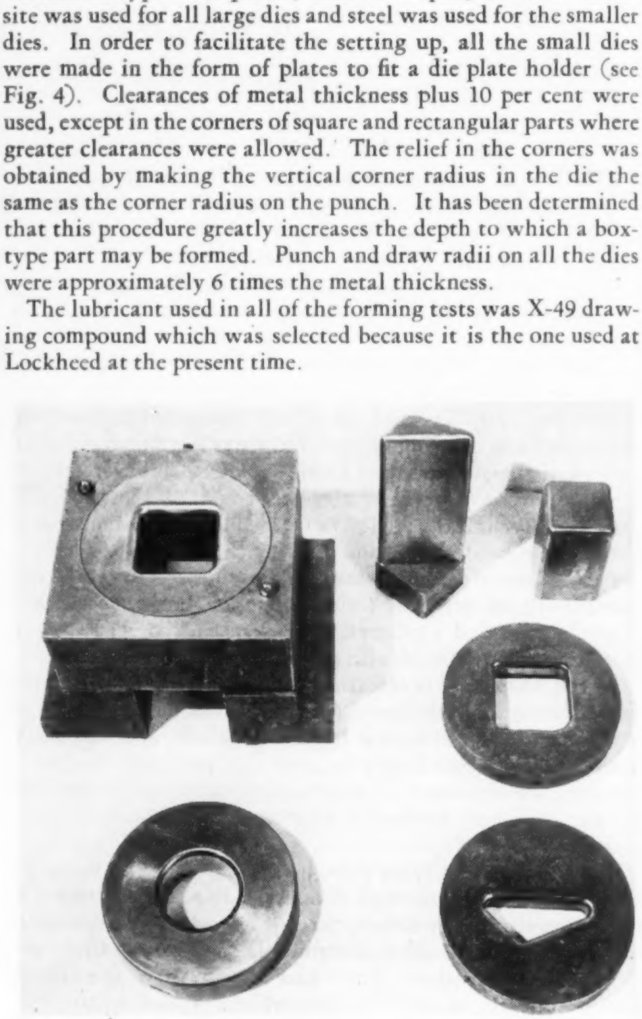

FIG. 4 INTERCHANGEABLE DIE PLATES AND DIE BASE

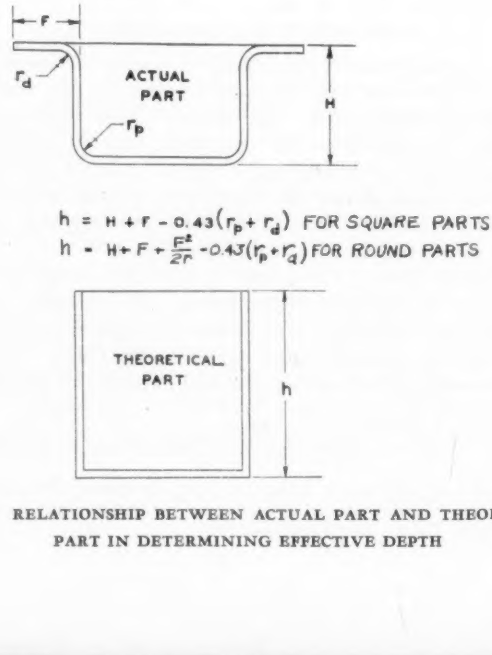

FIG. 5 RELATIONSHIP BETWEEN ACTUAL PART AND THEORETICAL PART IN DETERMINING EFFECTIVE DEPTH

Minimum values of hold-down pressure just sufficient to prevent wrinkles from forming were used. This pressure varied for each test, depending upon the shape and size of the die and the material being formed.

Material. The results reported in this paper are for 3S-$^1/_2$H aluminum-alloy material. This was chosen from among the various materials tested because of its consistency. The forming properties of various lots of this material were found to be more consistent than any of the other aluminum alloys. Several drawing tests were made on various lots of material so that the results would be typical for that material. Additional tests were also conducted in which all parts were made from the same sheet of material. The results reported in this paper are the ones obtained from the single sheet of 3S-$^1/_2$H material which had typical drawing properties.

Other materials were investigated in a similar manner; however, space does not permit giving detailed results.

Measurement of h. The value of the depth for a practical drawn part depends on the punch radius r_p, the draw radius r_d, and the width of the flange F. However, it was found desirable to use an effective value h for correlation purposes that would be comparable regardless of the value of r_p, r_d, and F. The effective depth h of a drawn part was defined as the depth of a theoretical part having the same total surface area but zero value for r_p (see Fig. 5). For a round part, h is expressed by

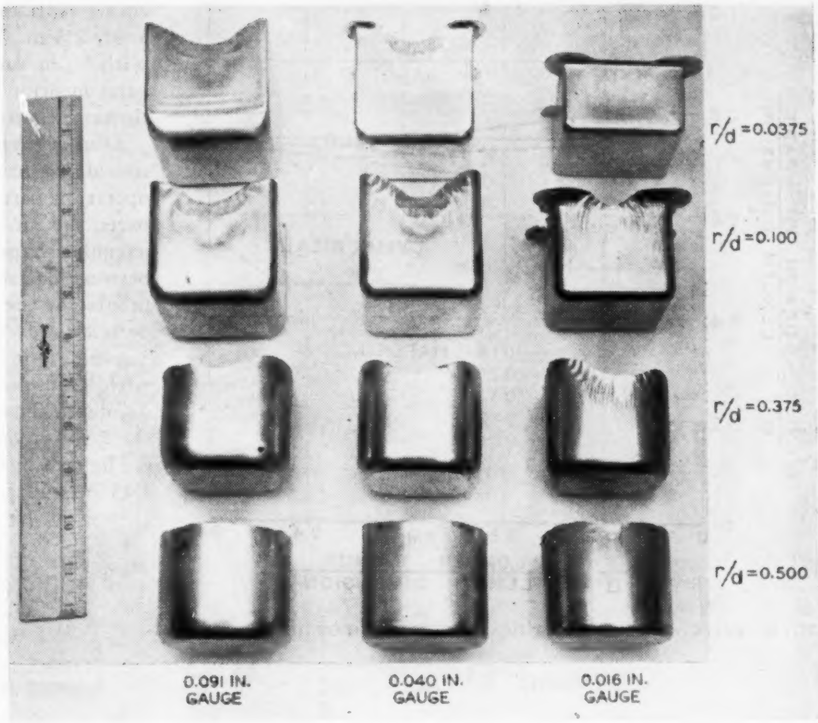

FIG. 7 EFFECT OF MATERIAL THICKNESS ON DEPTH OF DEEP-DRAWN PARTS FOR VARIOUS r/d VALUES

(d = 2.5 in. for all parts. Material: 3S-$^1/_2$H aluminum alloy.)

TABLE 1 EFFECT OF MATERIAL THICKNESS ON DEPTH OF DEEP-DRAWN PARTS. MATERIAL: 3S-$^1/_2$H ALUMINUM ALLOY

Description of part	r/d	Material thickness, in.	Drawing limits h/d
2.5-in-sq box	0.100	0.016	0.74
		0.025	0.81
		0.032	0.83
		0.040	0.75
		0.091	0.80
2.5-in-sq box	0.0375	0.016	0.57
		0.040	0.79
		0.091	0.79
2.5-in-sq box	0.375	0.016	0.71
		0.040	0.75
		0.091	0.74
2.5-in-diam cup	0.500	0.016	0.75
		0.025	0.75
		0.032	0.75
		0.040	0.75
		0.091	0.75

$$h = H + F + \frac{F^2}{2r} - 0.43\,(r_p + r_d) \quad \ldots\ldots\ldots [1]$$

where

h = effective depth
H = measured depth
F = width of flange
r = cup radius
r_p = punch radius
r_d = draw radius

This formula applies only to round parts. In the case of parts with flat sides, such as square or rectangular parts, the following empirical formula has been found to be useful

$$h = H + F - 0.43\,(r_p + r_d) \quad \ldots\ldots [2]$$

However, in this investigation all parts were fully formed, without flanges, and effective depths were computed by the formula

$$h = H - 0.43\,r_p \ldots [3]$$

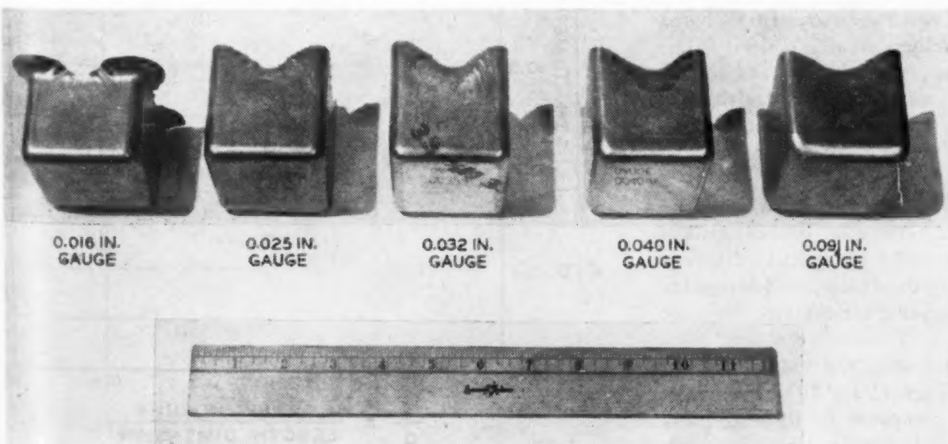

FIG. 6 EFFECT OF MATERIAL THICKNESS ON DEPTH OF DEEP-DRAWN PARTS

(d = 2.5 in. for all parts. r/d = 0.100. Material: 3S-$^1/_2$H aluminum alloy.)

RESULTS AND CORRELATIONS

Effect of Material Thickness. The experimental work consisted of determining the limiting depth which could be drawn from various thicknesses of material for one size part (see Table 1 and Fig. 6).

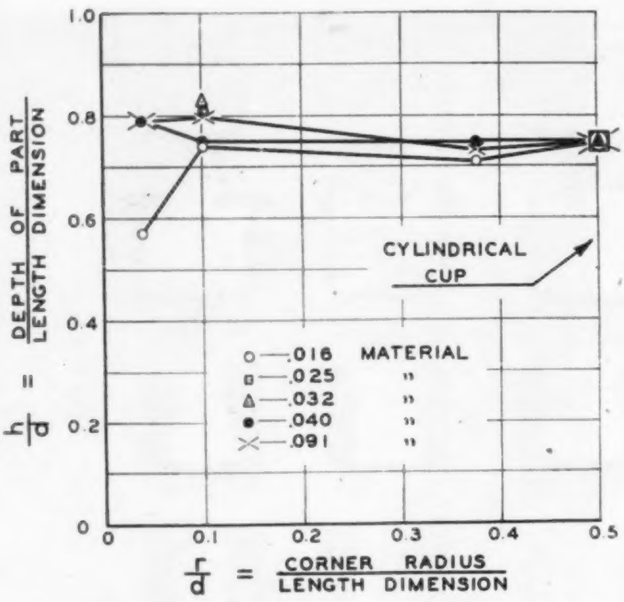

FIG. 8 EFFECT OF MATERIAL THICKNESS ON DEPTH OF DEEP-DRAWN PARTS

(Material: 3S-$^1/_2$ H.)

The effect of thickness was also investigated for various r/d ratios (see Fig. 7). Fig. 8 shows the effect of material thickness on the depth of drawn parts and indicates that, for material thickness greater than 0.020 in., the effect of thickness is negligible for the aluminum alloys.

With material thickness eliminated as a factor in determining the depth of drawn parts, the remainder of the tests were run on one thickness of material. The material thickness selected was 0.040 in. as it is one of the most common sizes used in aircraft parts.

Effect of (d) on the Depth of Deep-Drawn Parts. To determine the effect of the length dimension on the depth of deep-drawn parts, several parts were formed in which the length dimension was the only variable. The parts used were square boxes with $^5/_8$-in. corner radii and circular cups. The length dimensions of the boxes were 2.5 in., 4 in., and 6 in. The cup diameters were 2.5 in., 3 in., and 6 in. The limiting-size part was determined for each of these parts and the results are given in Figs. 9 and 10.

Effect of Corner Radius. The other variable investigated for square-shaped parts was the corner radius. As before, the other variables were held constant and the effect of r on the depth was determined. The test parts used were 2.5 in. square, and the corner radii varied from $^1/_{16}$ to $1^1/_4$ in. (see Fig. 11). The results for a 5-in-square part with $^1/_{16}$-in. corner radii are also included to demonstrate the effect of an extremely small r/d value. The limiting-size parts were drawn from round blanks and the results are presented in Fig. 12. It may be noted that the h/d value remains nearly constant for all values of r/d greater than 0.038. For values of r/d less than 0.038, a noticeable decrease in h/d was observed.

Effect of Size and Shape. The true test of the correlation of the dimensionless ratios was to select a number of different groups of parts in which each part of a particular group had a different geometrical size or shape, but the same r/d ratio; and determine if the limiting h/d values were the same for the two different sizes or shapes in each group.

Four groups of parts were tested with r/d values ranging from 0.10 to 0.50 (see Table 2 and Figs. 13 and 14). In three of the groups, the effect of size was compared by forming parts with the same geometrical shape and the same r/d ratio but with different geometrical sizes. In the other group, two parts with different shapes and sizes, but with the same r/d ratio, were tested. The parts were a 4-in-square box with $^5/_8$-in. corner radii and an r/d value of 0.156; and an equilateral triangle 2.5 in. long per side with the corners blended together with $^1/_4$-in. radii and an r/d value of 0.155. It is seen that the parts mentioned which have the same r/d values have nearly the same limiting h/d values regardless of shape or size.

Effect of Irregular Shape. Several other important items to be considered in the correlation of drawing limits for single-operation parts are the length-to-width ratio for rectangular parts, the effect of various radii on the same part, the effect of irregular shapes such as triangular, and the effect of the angle between flat sides. The tests for each of these conditions are tabulated, the results being presented in Table 3. The test parts are shown in Fig. 15. Failure in the 2.5-in-square part with $^3/_{32}$-in., $^1/_4$-in., and $^5/_8$-in. corner radii occurred in the corner with $^5/_8$-in. radius. It is also interesting to note that the limiting depth for this part was the same as the limiting depth for the 2.5-in-square part with $^5/_8$-in. corner radii.

The rectangular part that was investigated had a length = 4.45 in., width = 1.60 in. (length-to-width ratio = 2.78). The

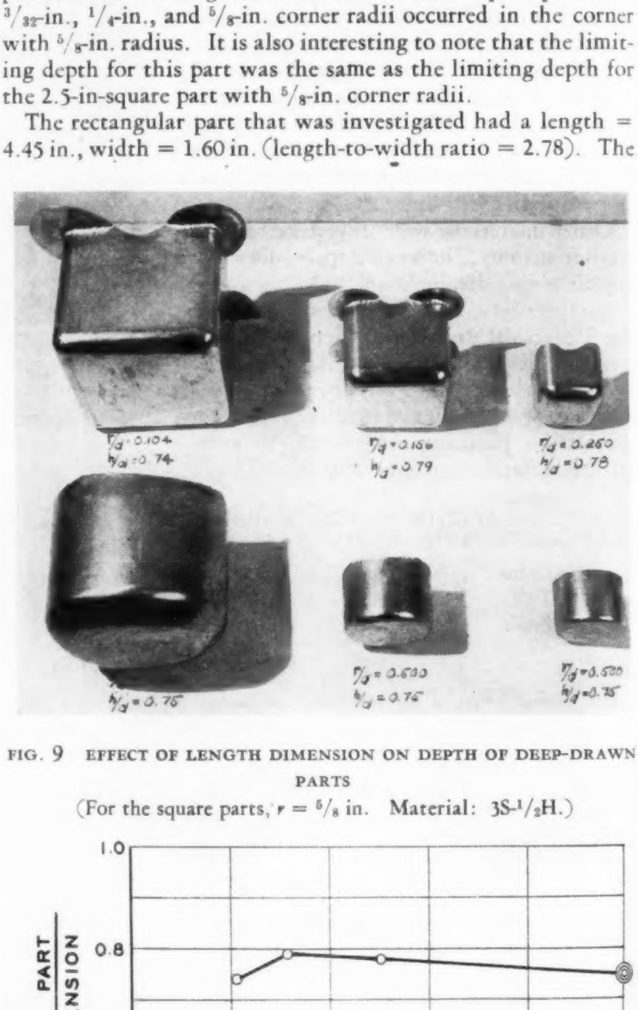

FIG. 9 EFFECT OF LENGTH DIMENSION ON DEPTH OF DEEP-DRAWN PARTS

(For the square parts, $r = {^5/_8}$ in. Material: 3S-$^1/_2$H.)

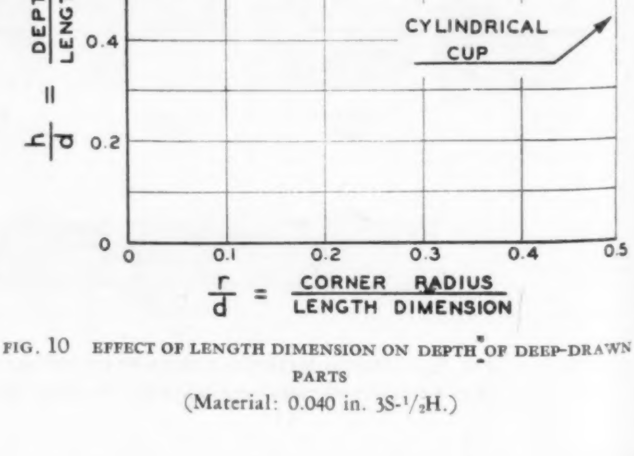

FIG. 10 EFFECT OF LENGTH DIMENSION ON DEPTH OF DEEP-DRAWN PARTS

(Material: 0.040 in. 3S-$^1/_2$H.)

TABLE 2 EFFECT OF SIZE AND SHAPE ON DEPTH OF DEEP-DRAWN PARTS. MATERIAL: 0.040-IN. 3S-$^1/_2$H ALUMINUM ALLOY

Description of part	r	r/d	Drawing limit h/d	No. on graph[a]
2.5 in. sq	$^5/_8$	0.250	0.73	5
6.0 in. sq	1.5	0.250	0.73	6
2.5 in. sq	$^1/_4$	0.100	0.80	1
6.0 in. sq	$^5/_8$	0.104	0.74	2
4.0 in. sq	$^5/_8$	0.156	0.76	4
Equilateral triangle, 2.5 in. sides	$^1/_4$	0.155	0.77	3
2.5 in. diam	1.25	0.500	0.75	7
3.0 in. diam	1.50	0.500	0.75	8
6.0 in. diam	3.00	0.500	0.75	9
10.0 in. diam	5.00	0.500	0.75	10

[a] See Fig. 14.

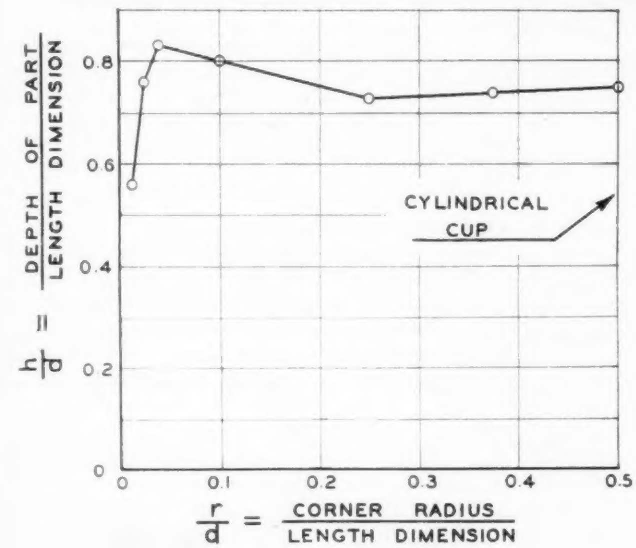

FIG. 12 EFFECT OF CORNER RADIUS ON DEPTH OF DEEP-DRAWN PARTS
(Material: 0.040 in. 3S-$^1/_2$H.)

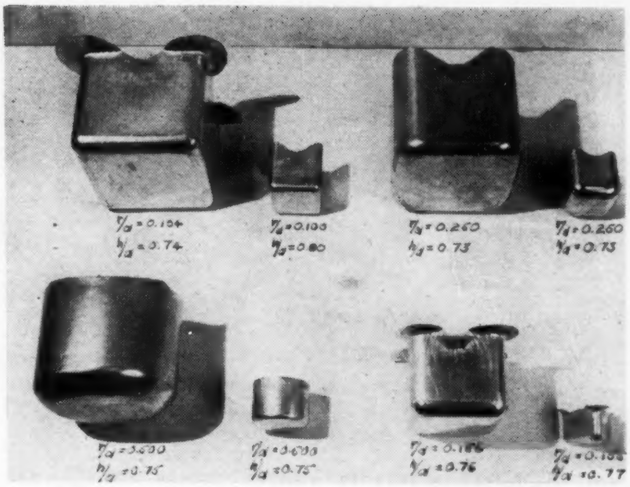

FIG. 13 EFFECT OF SIZE AND SHAPE ON DEPTH OF DEEP-DRAWN PARTS
(Material: 0.040 in. 3S-$^1/_2$H.)

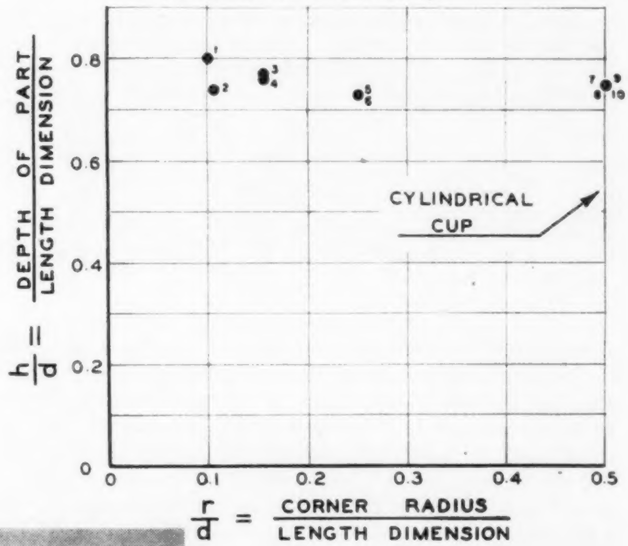

FIG. 14 EFFECT OF SIZE AND SHAPE ON DEPTH OF DEEP-DRAWN PARTS
(Material: 0.040 in. 3S-$^1/_2$H.)

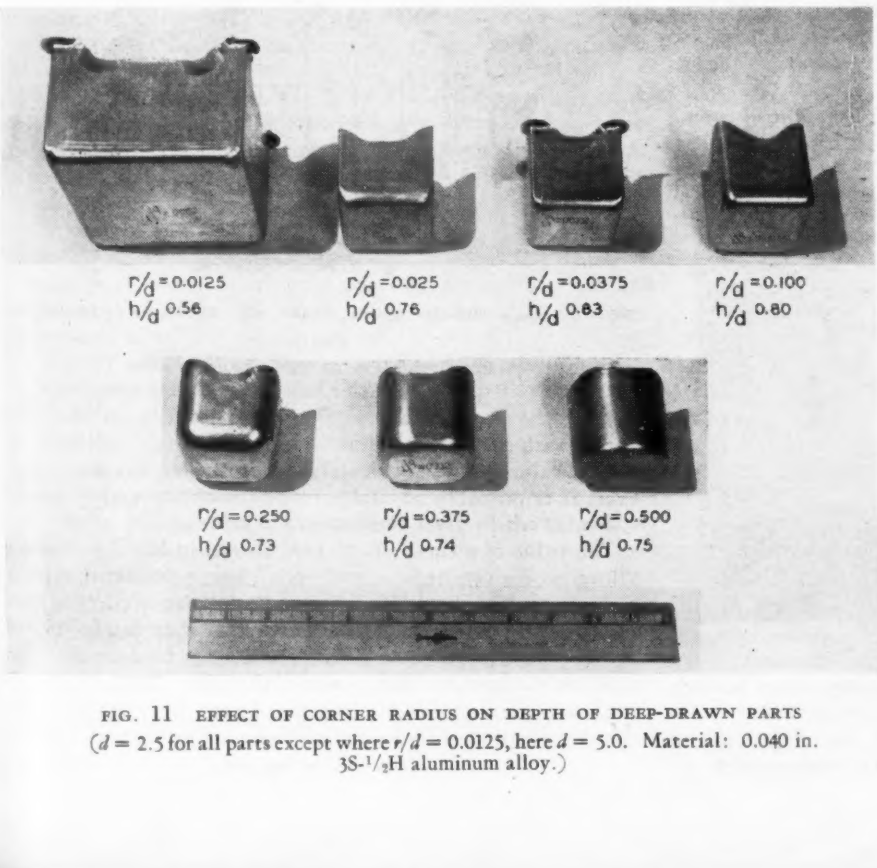

FIG. 11 EFFECT OF CORNER RADIUS ON DEPTH OF DEEP-DRAWN PARTS
(d = 2.5 for all parts except where r/d = 0.0125, here d = 5.0. Material: 0.040 in. 3S-$^1/_2$H aluminum alloy.)

limiting h/d for this part correlated very well with the rest of the data when d was calculated as the square root of the projected bottom area (see Fig. 15 and Table 3).

The effect of irregular shape and corner angle was investigated using two triangular parts. One was an equilateral triangle 2.5 in. long per side with $^1/_4$-in. corner radii and 60-deg corner angles. The other part was an oblique triangle with corner angles of 45 deg, 110.5 deg, and 24.5 deg, and the sides blended together with $^1/_4$-in. radii. The length of the short side between corner centers of the corner radii was $1^1/_4$ in. (see Fig. 15 and Table 3). The limiting h/d ratio for the equilateral triangle correlated very well when the d dimension was determined as the square root of the projected bottom area. A circular blank was used for this part. The d dimen-

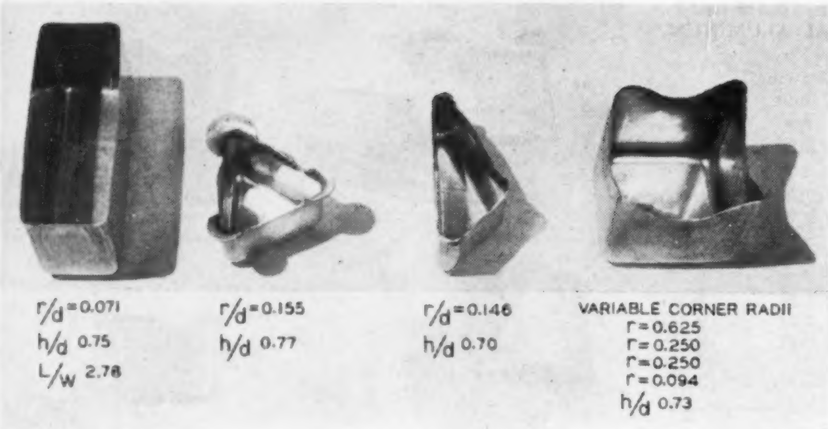

FIG. 15 EFFECT OF IRREGULAR SHAPE, CORNER RADII, AND l/w RATIO ON DEPTH OF DEEP-DRAWN PARTS

(Material: 0.040 in. 3S-$^1/_2$H aluminum alloy.)

TABLE 3 RESULTS OF EFFECT OF IRREGULAR SHAPE ON DEPTH OF DRAWN PARTS. MATERIAL: 0.040-IN. 3S-$^1/_2$H ALUMINUM ALLOY

Description of part	r	r/d	Drawing limit h/d
2.5 in. sq	$^3/_{32}$, $^1/_4$, $^1/_4$, $^5/_8$		0.73 Limited by $^5/_8$ in. radius
1.60 × 4.45 in. rectangle	$^3/_{16}$	0.071	0.75
Equilateral triangle, 2.5 in. sides	$^1/_4$	0.155	0.77
Oblique triangle, side angles = 45 deg, 110.5 deg, and 24.5 deg	$^1/_4$	0.146	Limited by the 24.5-deg corner angle 0.70

sion of the oblique triangle was calculated in the same way but the limiting h/d was lower than for other parts with a corresponding r/d value. The depth of the part was limited by the 24.5-deg corner angle. The blank development for this part was troublesome because of the odd shape, the sharp corner angle, and the location of the blank on the die. From the results obtained it is indicated that the values of h/d do not correlate with those for other parts when the angles between sides are as small as 24.5 deg. In general, it is believed advisable to limit the design of parts to a minimum corner angle of not less than 45 deg.

Correlation of All Results. The results from all of the foregoing tests are shown grouped together in Table 4. In Fig. 16, it is

TABLE 4 CORRELATION OF ALL RESULTS ON EFFECT OF SHAPE ON DEPTH OF DEEP-DRAWN PARTS. MATERIAL: 0.040-IN. 3S-$^1/_2$H ALUMINUM ALLOY

Part no. (see Fig. 16)	Description of part	Corner radius, in.	r/d	Drawing limit h/d
1	5.0 in. sq	$^1/_{16}$	0.0125	0.56
2	2.5 in. sq	$^1/_{16}$	0.025	0.76
3	2.5 in. sq	$^3/_{32}$	0.0375	0.83
4	4.45 × 1.60-in. rectangle	$^3/_{16}$	0.071	0.75
5	2.5 in. sq	$^1/_4$	0.100	0.80
6	6.0 in. sq	$^5/_8$	0.104	0.74
7	Oblique triangle	$^1/_4$	0.146	0.70
8	Equilateral triangle	$^1/_4$	0.155	0.77
9	4.0 in. sq	$^5/_8$	0.156	0.76
10	2.5 in. sq	$^5/_8$	0.250	0.73
11	6.0 in. sq	$1^1/_2$	0.250	0.73
12	2.5-in. sq	$^{15}/_{16}$	0.375	0.74
13	2.5-in-diam cup	1.25	0.500	0.75
14	3.0-in-diam cup	1.50	0.500	0.75
15	6.0-in-diam cup	3.00	0.500	0.75

demonstrated that all the results for this material may be combined into a single curve by plotting the dimensionless ratios h/d and r/d. Thus it is indicated that the limiting depth of any single-operation drawn part of the type investigated, regardless of size and shape, may be determined from this type of curve.

Discussion of Results. The results presented in Fig. 16 indicate that the value of h/d depends almost entirely upon the ratio r/d. This applies to parts other than round or square, provided d is then determined as the square root of the bottom area. Within certain ranges of r/d, it may even be said that the value of h/d is practically constant, that is to say, h depends only upon d.

There is reason to believe that the expression

$$d = \sqrt{\text{Projected bottom area}} \quad \ldots\ldots [4]$$

cannot be used for rectangular parts when the ratio of length to width is very large. For ratios greater than 3, it is suggested that d be computed by the empirical formula

$$d = 1.73\,w \quad \ldots\ldots\ldots\ldots [5]$$

where w = width of part.

In the case of some material, considerable variation in limiting values of h/d has been observed owing to variation in the properties of the material. In the case of 24S-0 material, extreme variations in formability were encountered in different sheets of material. It follows that allowances must be made for variations of material in constructing a curve that is suitable for design purposes.

The results of the tests on the 2.5-in-square part with various corner radii indicated that such parts are not necessarily lim-

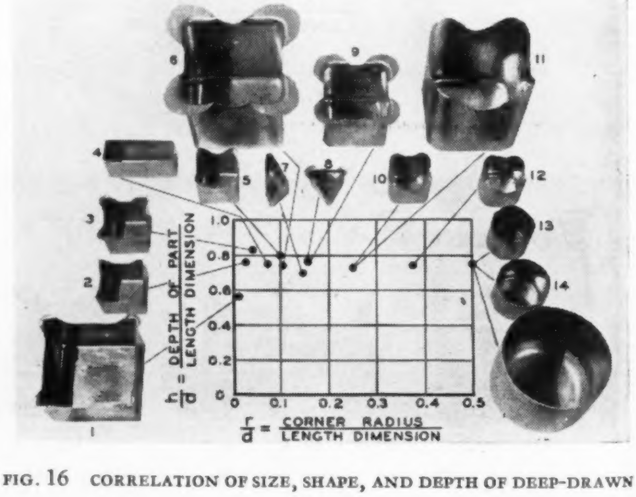

FIG. 16 CORRELATION OF SIZE, SHAPE, AND DEPTH OF DEEP-DRAWN PARTS

(Material: 0.040 in. 3S-$^1/_2$H aluminum alloy.)

ited by the smallest radius. This part actually failed in the corner with the largest radius. The results would indicate that the r/d value should be calculated using the large radius; however, it is probably advisable to be conservative and use the r/d value which gives the lowest h/d value.

The value of a curve of the type shown in Fig. 16 (making allowance for variations in materials), lies in the fact that parts to be formed by deep-drawing may be accurately checked during the design stage to determine whether they can be formed in one operation or not. The procedure is to determine the value of r/d from the dimensions of the part. The corresponding limiting value of h/d is determined from the graph and compared with the h/d of the part. If the h/d of the part is equal

(*Continued on page 662*)

Postwar AVAILABILITY and USE *of* WOOD

By FRANK J. HANRAHAN

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LIKE every other large industry, the forest-products industry has given serious thought to postwar markets. However, being fully occupied with fulfilling present war needs, our industry has neither published extensive postwar analyses nor taken part in hair-raising postwar predictions. This paper is intended to develop certain pertinent information and data from which the reader may draw his own conclusions as to the postwar availability and use of wood.

IMPORTANCE OF FOREST-PRODUCTS INDUSTRY

The forest-products industry (1, 2)[1] is one of the nation's oldest and largest industries. Authentic records show that there were sawmills in Jamestown in 1608, and it is probable that there were earlier mills in the older settlements. The 1939 census report rates the industry fourth in number of employees and sixth in value of products.

The capital investment in the forest industries of the United States is approximately $10,000,000,000. The 22,000 forest-products concerns reporting to the Bureau of Census in 1939 employed approximately 1,000,000 persons, and it has been estimated that more than 2,000,000 persons are directly dependent on the forests and forest products for their livelihood.

In an average year, the United States accounts for 43 per cent of the world's forest production. The United States makes over 50 per cent of the world's paper and for more than a century has produced from 65 to 80 per cent of the world's annual production of naval stores.

An attempted census of the uses of wood once reached a count of 4500 without even approaching a full or exhaustive classification. Even in our large cities remote from the forests, it would be difficult, if not impossible, for one to disassociate himself, even momentarily, from wood in some form or other.

WAR NEEDS

Lumber and other forest products have enlisted for the duration. War requirements are such that, in general, substantial amounts of lumber will not be available for ordinary civilian uses until cessation of activities in at least the European theater (3).

Present war needs are well exemplified by the following excerpts from a recent speech (4) by J. Philip Boyd, Director of Lumber and Lumber Products Division of the War Production Board:

"First and foremost, wood is the only material which has the adaptability and the strength to become the package, the enormous package, in which must be enclosed the stupendous volume of war matériel and supplies which we must ship abroad to our fighting forces all over the world. Last year we produced almost 35 billion feet of lumber in this country and this year over half of that will go for one single purpose of packaging and crating the great movement of goods that is being poured forth under our war-production schedule. That

FIG. 1 THREE VIEWS, ILLUSTRATING THAT TREES ARE A CROP, WERE TAKEN OF THE SAME SPOT (MARKED "X") IN A SOUTHERN FOREST IN 1930, 1935, AND 1939

(Seed trees, shown in the background of the 1930 photograph, seeded the area.)

[1] Numbers in parentheses refer to the Bibliography at end of paper.

Contributed by the Wood Industries Division of The American Society of Mechanical Engineers.

is conservatively four times as much lumber as is used for these purposes in peacetime.

"Everything that goes overseas which is in any way made of metal—and that includes most everything except food and clothing—must be tightly boxed; not boxed as for domestic shipment but completely boxed to protect it from the salt air and its effect on metal.

"No ship in a convoy leaves port—unless it has a bulk cargo of some kind—without using about 10 carloads of dunnage just to pack the cargo and keep it from shifting within a ship.

"Every time we send a man overseas it takes three hundred feet of lumber to box and crate the initial supplies for that man and nearly 50 feet a month from there on to keep him supplied and that is just to supply that soldier; it doesn't include all of the other vast armament of war.

"It took a tidy little amount of lumber, almost 50 million feet or pretty close to two thousand prewar carloads just to put that port of Naples back into shape so that we could use it on a temporary basis.

"When we took Tarawa there was not a single structure as big as a matchbox left intact on that island. There had to be a shipload of lumber follow those troops ashore to give the wherewithal to make the place habitable and to afford temporary protection. There is no other material that covers all of these multitudinous purposes and which can be used for almost any need of an emergency nature.

"One of the things that has added to the lumber job in this war is that the Western Hemisphere is carrying the entire burden of supply. So far we have acquired the habit of conquering largely desolate and unforested places. We are denied access to the forest products of Scandinavia and of Finland, and of France.

"The policy of the Lumber Division of the War Board has always been to do what was necessary for the war first, but always to do it with the least possible disruption of normal trade channels and of normal essential civilian requirements."

Besides the enormous quantities of lumber used in direct war activities and war construction, great quantities of wood in the form of pulp for paper products, fuel, veneer for plywood, laminated and molded products, poles and piling, ties, wood flour, cellulose for explosives, textiles, and other chemical processes, and in many other forms are demanded for war purposes.

POSTWAR AVAILABILITY OF WOOD

Such great demands on our forests raise questions as to our future supply of timber (1, 2, 3). In fact, for many years, there have been dire predictions that our timber would soon be exhausted.

In 1832, J. D. Brown, writing in ***Sylva Americano*** asked: "Where shall we procure supplies of timber fifty years hence for the continuance of our Navy?" Although the total tonnage was somewhat less, in 1942, not 50 but 110 years after this prediction, we produced three times as many wooden ships as our yards turned out in 1855, peak year of sailing-ship construction.

In 1875, Secretary of the Interior, Carl Schurz, declared in his annual report that within 20 years the timber would be so far gone as to "fall considerably short of our home necessities." According to this prophecy, our nation has been starved of timber for 49 years!

In 1908, Gifford Pinchot, then United States Forester, proclaimed: "We have in store timber enough for only twenty or thirty years;" and "A timber famine is the inevitable event of our near future." According to this pronouncement, made 36 years ago, we have been out of timber for a decade and Mr. Boyd's statements, previously quoted, on present war consumption of domestic lumber must be pure figments of the imagination.

Even today similar ridiculous claims are widely circulated. For the most part these alarmists neglected to consider the simple fact that timber is the nation's greatest renewable resource, that is, it is a growing crop, not a depletable mine. Also, that trees will grow and reproduce themselves with but scant encouragement (see Fig. 1).

TABLE 1 DISTRIBUTION OF SAW TIMBER BY REGIONS

Region	Per cent
Pacific Northwest	50
South	22−
California	12+
Southern Rocky Mountain	7+
Northeast	5−
Lake	3+
Central	1−
Total	100

TABLE 2 DISTRIBUTION OF SAW TIMBER BY SPECIES

Species	Billion board feet
Eastern softwoods:	
Southern yellow pine	197−
Spruce and fir	24+
White and red pine	18+
Hemlock	18−
Cypress	12−
Others	9−
Total	277−
Eastern hardwoods:	
Oak	84−
Birch, beech, maple	55+
Red gum	28−
Tupelo	20+
Yellow poplar	10−
Cottonwood, aspen	8+
Others	61−
Total	266−
Western softwoods:	
Douglas fir	490−
Ponderosa pine	225−
True fir	122−
Western hemlock	116−
Spruce	63−
Redwood	39+
Lodgepole pine	39−
Western larch	25+
Sugar pine	25−
Western white pine	18+
Others	55−
Total	1216+
Western hardwoods:	5−
All species	1764−

TABLE 3 RATIOS OF ANNUAL DRAIN TO GROWTH (1936) BY REGIONS FOR SAW TIMBER AND CORDWOOD COMBINED

Region	Ratio
Northeastern	1.1
Central	1.6
Lake	1.0
South	1.0
Pacific Northwest	1.7
California	3.2
South Rocky Mountain region	0.8
Total	1.2

The extent of our timber resources is usually underestimated (1, 2). About one third of the area of the United States is forested. This is about one and one-half times as much area as in food and textile crops, or nearly 5 acres of forest land for each man, woman, and child. According to the latest United States Forest Service statistics (1936–1938 revision) there are now in the United States 630,000,000 acres of forest land of which 462,000,000 is commercial forest land, capable of producing timber of

commercial quantity and quality, and available now or prospectively for commercial use. The total stand of saw timber, excluding trees smaller than 9 to 15 in. diameter, depending on cutting practices of the area, is 1764 billion board feet.

The quantitative distribution of saw timber is given by regions in Table 1, and by species in Table 2.

The stand of cordwood (below saw-timber size) on saw-timber, cordwood, and restocking areas is estimated to be 2455 million cords of which 56 per cent is hardwood.

The ratios of annual drain to growth by regions for saw timber and cordwood are given in Table 3.

From these data it will be noted that, although we have a large timber inventory, the rate of drain for recent years has exceeded the rate of growth. However, there are at work many factors which tend to bring a balance in the near future. Industry and government alike are concentrating on reforestation, forest management, and protection of forests from fire and insects.

Recently Congress passed laws which make it easier for private individuals to grow trees. It has authorized greatly increased funds for fire prevention. The Government will cooperate with private owners to form forest units large enough to permit efficient forest operation on a sustained yield basis, i.e., continuous operation by harvesting only the equivalent of a year's growth. It has authorized funds to enable the Federal Government to complete a national forest survey to provide facts instead of guesswork. It has enacted tax laws which tend to encourage more forest growth on privately owned land.

Mr. G. H. Collingwood, chief forester of the National Lumber Manufacturers Association, which is closely identified with intensive promotion of forest conservation among forest owners, has stated:

"Effective achievement of fire-protection goals with accompanying progress in cutting and utilization methods promises favorable balance in fifteen to thirty years."

Forest products are subject to the same economic laws of supply and demand as other articles of commerce. Hence the extent to which private forest owners can support increasing forest growth is dependent on the extent to which wood utilization makes commercial timber growing a business for profitable investment.

With respect to the future availability of timber, Lyle F. Watts, Chief, Forest Service, United States Department of Agriculture, has said (5):

"Wood, in contrast to so many other engineering materials, is a crop and the supply can be renewed indefinitely. But like other crops produced from the soil, the growing of the needed quantity and quality of product requires the application of sound management practices. Except where the stands consist chiefly of virgin timber, as in parts of the West, the quantity of timber cut each year should not exceed the growth of usable timber. The only acceptable philosophy for balancing the drain with the growth is to grow more timber—not to use less. If reasonably good forest practice is applied generally throughout the country, we may expect to build up forest growing stock in the course of the next century to yield a cut of 21 billion cubic feet annually. This is substantially in excess of the current rate of utilization and should be ample for all foreseeable needs."

PREWAR USES OF WOOD

In anticipating postwar uses of wood, it is helpful to review prewar uses (1, 2).

According to United States Forest Service (1936–1938 revision) data, the timber removed from the commercial forests of the United States by cutting and destructive agencies in 1936 was as indicated in Table 4 (1).

In 1940, lumber was consumed as indicated in Table 5 (1).

In the principal manufactured products, the order of consumption by volume is: boxes, baskets, and crating; sash, doors, and millwork; flooring; furniture. However, even relatively minor uses consume large quantities. For example, although water storage is but one of many uses of wood tanks, it has been estimated that if the water stored in wood tanks were placed in one huge vat, it would float our nation's Navy.

TABLE 4 TIMBER REMOVED FROM COMMERCIAL FORESTS OF UNITED STATES BY CUTTING AND BY DESTRUCTIVE AGENCIES, 1936

Item	Million cubic feet	Per cent
Lumber	5368—	40—
Fuelwood	3619+	27—
Pulpwood	706—	5+
Hewed ties	354+	3—
Fence posts	327+	2+
Veneer logs	252+	2—
Mine timbers (round)	161+	1+
Cooperage	149+	1+
Shingles	109—	1—
Other	354+	3—
Fire	862—	6+
Insects, disease, etc	1201+	9—
Total	13,463—	100

TABLE 5 LUMBER CONSUMPTION

Item	Per cent
Building and construction (excluding railroads)	67
Boxing and crating	14
Industrial	10
Railroad	6
Export	3
Total	100

POSTWAR UTILIZATION OF WOOD

Postwar uses of wood (1, 2, 3) may be classified as traditional prewar uses and new uses emanating from recent technical developments, many of which resulted from meeting special war requirements.

Present indications are that the war's end will not bring a reduction in the traditional uses. In fact, because of the backlog of civilian needs built up during war, there is every reason to expect that when additional civilian manpower becomes available after the war there will be substantial increases in commonplace uses.

Dr. Wilson Compton, secretary-manager of the National Lumber Manufacturers Association, has stated (3):

"We will end the war with the most pressing housing shortage in history."

It is predicted that we will be building from 600,000 to 1,000,000 homes a year for 10 years, starting soon after hostilities cease. It has been estimated that the home and farm improvement program will total $6,000,000,000. Undoubtedly, commercial construction and remodeling will also account for a sizable volume of postwar lumber.

A recent survey of postwar requirements of some leading railroads made by Verne Ketchum (6) indicates that one railroad will increase its normal annual use of 4,000,000 fbm a year to 5,000,000 or 6,000,000 for 5 years after the war. Another will use 3,000,000 to 4,000,000 fbm per year together with some 250,000 linear ft of timber piling. Another railroad expects a 27 per cent increase over normal requirements for timber construction including annual use of 6,000,000 fbm for ballasted deck bridges and 3,000,000 for open deck bridges. Only two railroads contemplated return to more normal timber-construction programs.

There is a backlog of 18,000,000 radio sets requiring cabinets, to say nothing of the requirements of the furniture, motor-vehicular, shipbuilding, and other large wood-consuming industries.

In June, 1944, the following editorial comment was made (7): "At the moment lumber is scarce due to war demands but after the war its field of usefulness should be expanded as a result of what we have learned about it during war years."

NEW USES AND TECHNICAL DEVELOPMENTS

Although traditional uses will play a large part in the volume of immediate postwar markets for wood, there is a whole horizon of new developments which indicate practically unlimited possibilities for increased uses of wood (5). These take the form of both improvements of the older products and development of entirely new products. These developments, many of which were in evidence prior to the war, stem largely from technical findings. After many years of neglect, technical men are taking a renewed interest in wood as a material and are constantly finding amazing new facts which will extend its future use. Because of its previous neglect but present rapid potential growth, technical development of wood holds forth one of the most promising of careers for technical men.

Progressive schools are devoting more time to instruction and research on wood. For example, the Timber Engineering Company conducted a survey in 1936, which showed that only 31 professors in 23 universities were teaching timber engineering. The 1943 survey revealed that, out of 224 replying, 188 professors in 135 universities taught timber engineering. Although Army and Navy training programs undoubtedly were a factor in the results of the 1943 survey, the trend was definitely upward before the war from 1936 through 1940. Further, 144 of the professors in the 1943 survey stated that they intended to continue these courses after the war.

This renewed interest in structural design in timber was greatly stimulated by improved timber connecting devices developed and made commercially available by the Forest Products Laboratory and Timber Engineering Company, an industry-owned organization established for this purpose. Undoubtedly the increased technical knowledge of wood accumulated and published in the last 10 or 15 years is a major factor in greatly expanding timber construction. Among other progressive steps, adequate technical knowledge of the material has resulted in the use of higher working stresses and accurate commercial selection of lumber for specific purposes.

Improved dry kilns and chemical seasoning of wood are developments which were growing rapidly even before the war, i.e., being used by many mills. As L. J. Markwardt, Assistant Director of the United States Forest Products Laboratory, has stated (5):

"Seasoning losses in some of the large timbers, which formerly ran from 40 to 60 per cent, have been reduced to less than 5 per cent. Not only are seasoning losses reduced, but the drying time is also decreased."

Another development growing rapidly before the war and accelerated by the war is the use of glued lumber and veneer. Glued wood takes a multitude of forms, such as laminated lumber, plywood, molded products, etc., and is used extensively in practically any field one could name (see Fig. 2). This was made possible by recent developments in wood glues and gluing techniques which will meet the requirements of any condition of service. With glue as strong as the wood itself, the size of the tree from which the wood comes assumes less significance.

The growing use of effective commercial treatments for increasing the resistance of wood to decay, termites, fire, marine borers, and other items under conditions unfavorable to untreated material is extending the range of common wood usages.

Important prewar advances have been made in chemical uses of wood such as paper products, rayon, cellophane, lacquers, photographic film, and other cellulose products.

These are but a few of the many new prewar developments which are now in substantial commercial use and accomplishing substantial conservation of material by more complete utilization of the tree.

More recent significant research developments permit changing the very properties of wood (see Fig. 3). The various strengths, resistances to previously destructive agencies, dimensional change, and many other factors can be regulated practically at will through various processes and treatments.

Compregnated wood (compreg) is an example. In general the various strengths of wood vary with some function of the dry-wood specific gravity. When the specific gravity of Sitka spruce is raised from 0.40 to 1.32 through impregnation with resins and compression under heat, the modulus of rupture becomes 43,400 psi, the tensile strength 42,500 psi, and the modulus of elasticity 4,420,000 psi, $4^1/_4$, $2^1/_2$, and $2^3/_4$, respectively, times that of the dry natural wood. Although spruce is strong for its weight, it is not considered one of the stronger domestic woods. However, as compregnated wood, it exceeds the strength of any domestic wood. This process may be used with similar results on practically any species, i.e., our lightest woods can be made stronger than our strongest natural woods. Using this process, the rates of growth and specific gravities of the natural wood become of little importance. Compreg is used for many articles of war.

Even without impregnation, under optimum conditions of temperature, moisture, and pressure, the natural lignins will flow to form dimensionally stabilized wood (staypak) having physical properties similar to those of compreg.

Also, with impregnation but without compression, the wood may be given added hardness, a permanent finish, and other properties desired for some uses.

High-strength, laminated, impregnated paper (papreg) has been developed and used for aircraft and other parts. Properties depend on the paper base used but one type of available commercial paper laminate conforms to specifications requiring modulus of rupture of 32,000 psi, tensile strength of 36,000 psi, and modulus of elasticity of 3,000,000 psi.

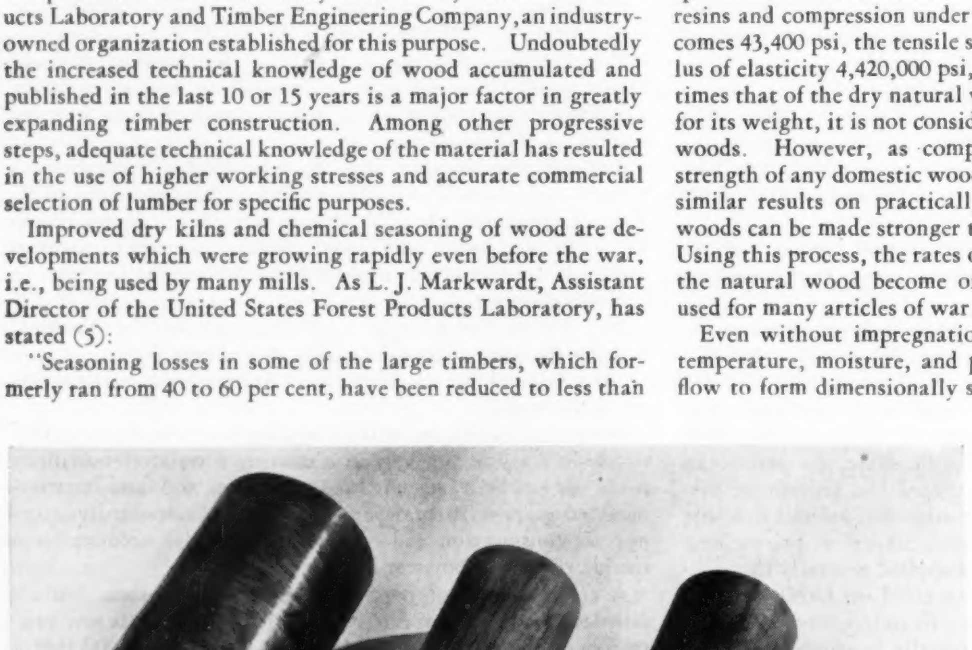

FIG. 2 VARIOUS TYPES OF PIPE ARE MADE OF WOOD VENEER JOINED BY RESIN ADHESIVES

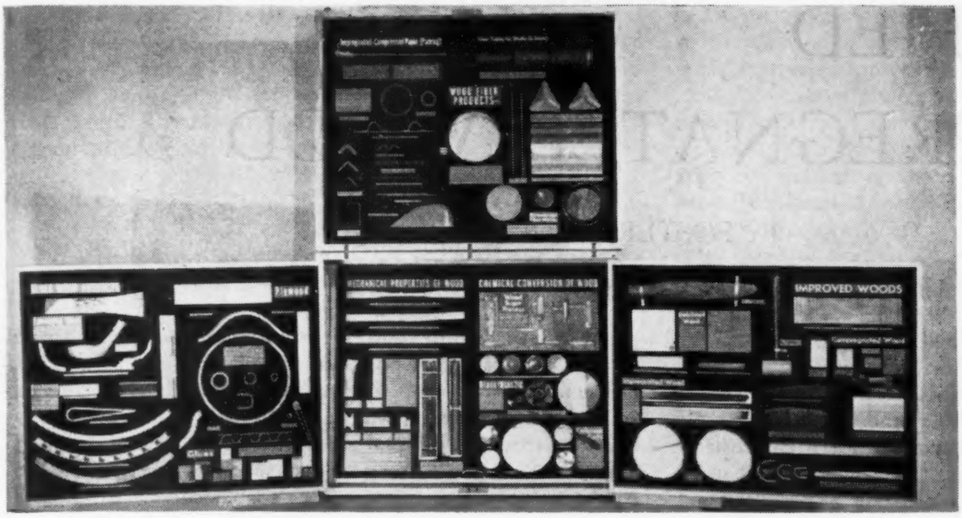

FIG. 3 MOUNTED IN THIS CASE ARE SAMPLES OF OVER 100 NEW DEVELOPMENTS IN WOOD

For ease in forming complicated shapes, wood may be plasticized by impregnation and heat, shaped to desired form, and upon cooling retain the original wood properties in the desired form. The resultant product may be made thermoplastic (again becoming plastic upon heating) or thermosetting (not becoming plastic upon heating) by variation in the treatment (see Fig. 4).

One of the most active fields of research and development at the moment is wood hydrolysis which uses wood sawdust, chips, or other wood waste. Various processes employing acids are used to break down the wood cellulose to form sugar and other products leaving lignin as a by-product. After being neutralized, the sugar may be further refined into various products such as alcohol, feeding yeast, or for most any other purpose for which glucose can be used. This alcohol is ethyl, not wood alcohol. Although at present the chief value of the waste product lignin is as a fuel, experiments on the use of lignin as rubber extenders, plastics, adhesives, acid- and oil-proof coatings, fertilizer, water and gas purifiers, are under way.

New processes for supplying heat for seasoning and gluing wood include the application of high-frequency electric fields by which the wood package is heated throughout as quickly as at the surface. Since wood is a poor conductor of heat, in some cases this process reduces the time required from hours to minutes and from minutes to seconds, thereby holding forth promises for continuous processes in drying or gluing.

New molding processes employing forms with various methods of applying pressure and heat simultaneously to wood have been developed and used extensively for manufacturing complicated articles of war.

During the war, numerous new finishes and protective coatings for wood have been developed which will resist oil, gasoline, and various chemicals and thereby extend postwar applications for wood.

Many new wood composite products such as veneer or plywood, covered with compreg, papreg, cloth, glass cloth, metal, resin treatments, and other materials in various colors and molded in various shapes have been developed for war uses requiring certain surface characteristics and shapes. Many of these new wood products have escaped attention because of their present restriction to wartime needs.

CONVERSION FROM WAR TO PEACE CONDITIONS

By and large, the lumber and wood-products industry has no postwar conversion problem. The equipment, machinery, and processes used for war production are essentially the same as those required for peace production. The principal effect of the war has been to divert products from civilian to war uses. When war needs are ended, the products will again flow into civilian channels without delay (3).

CONCLUSIONS

After examining the preceding and other pertinent data, the personal opinions of the author are as follows:

1 There will not be a postwar shortage of timber.

2 There will be an increase of the immediate postwar use of wood, if for no other reason than because of the large backlog of civilian and world reconstruction requirements, and, in the long-time trend, the increased attention paid to technical development of wood will be an important factor.

3 Judged by the present rapid growth of technical development in both old and new wood products and opportunities made easily available through long neglect of the field, technical development of wood products provides exceptional opportunities for technically trained men.

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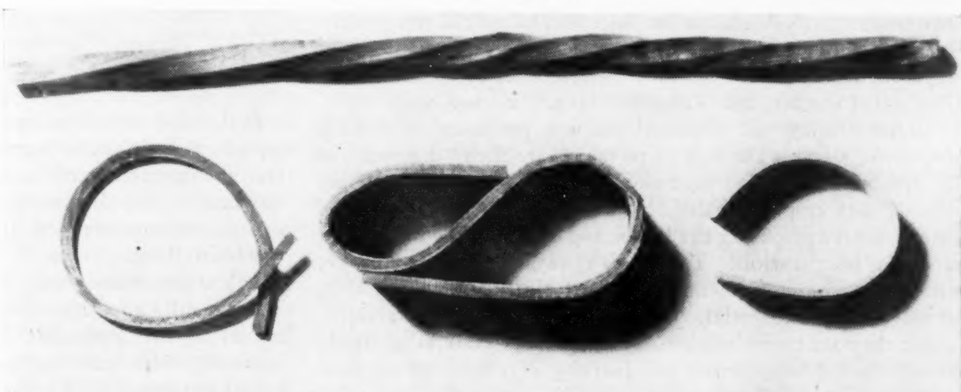

FIG. 4 NEW PROCESSES HAVE MADE IT POSSIBLE TO SOFTEN WOOD SO THAT IT MAY BE TWISTED AND BENT TO ALMOST ANY DESIRED SHAPE

DELIGNIFIED IMPREGNATED WOOD

By FOSTER LUCE

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IMPROVEMENT of natural wood has been the subject of considerable research during the last few years. For the most part these "improved woods" are made of veneers which have been impregnated with a stabilizing material or have been bonded with resins and compressed to high densities. As a possible improvement over existing techniques let us introduce one preliminary step and before impregnating or bonding the veneer layers, treat the wood chemically with heat and pressure, much as the paper manufacturer does, in order to convert the lignin and substantially remove it from the wood along with the other unstable components, but without destroying the wood structure. We call this treatment "delignification," although other incidental reactions must be included. In order to clarify discussion, we must take notice that although a tremendous amount of research has been done on wood chemistry and great advances have been made, yet there is no full agreement among the experts as to the exact chemistry of the wood components or to that of the various pulping reactions. We must therefore base this treatise upon the more generally accepted theories, leaving final proofs to the future.

DELIGNIFICATION AND IMPREGNATION PROCESSES

To the process of delignification we must add that of impregnation, as the end products being considered are combinations of delignified wood and various impregnating materials, such as natural or synthetic resins. These two processes result in materials which are quite unlike wood in many respects, are more uniform, have greater dimensional stability, and offer to the engineer a more reliable material, capable of easy fabrication. Owing to their low densities and unusual weight-strength relations, it may be possible that these materials may be useful to engineers in our great aircraft industries as well as to other weight-conscious groups. It must be admitted at the start that this development, on which patents are pending, is now only two years old and is still not much more than a laboratory curiosity. Much is yet to be done to explore fully the possibilities of the process and establish proper controls.

Elementary wood chemistry teaches that wood substance is composed of about 50 per cent pure cellulose, 25 per cent hemicelluloses, and 25 per cent lignin, with small amounts of other materials. Cellulose forms the basic fiber of the cell wall, hemicelluloses are classed as "intermediate products," and lignin is regarded as the cement or binder which holds the vertical hairlike cells together, and is therefore largely intercellular.

In performing the chemical pulping processes of making paper the wood is cut into chips which are then "digested" in a "liquor" under high heat and pressure. Several systems are in use, each employing different chemicals or combinations of chemicals for preparing the liquor and each varying in the heat and time of operation. The aim is always the same, to remove the wood components other than the cellulose, the stable, strong, fibrous material. Hemicelluloses are undesirable because they are essentially unstable and weak materials; lignin is not wanted in any but small quantity as it weakens the final paper product and of course, it must be removed or weakened so that the hairlike wood cells may be easily separated and cleaned. Thus the papermaker removes the inferior and unstable portions of the wood substance, but in so doing he entirely destroys the natural strength-giving orientation of the fibers. He must then rearrange them on a papermaking machine and reweld them into a continuous sheet with more or less random orientation and with all the natural bonds obliterated.

BORROWING PAPERMAKING TECHNIQUE FOR DELIGNIFICATION

This procedure is sensible considering the end product desired, but let us so control the digestion processes that the wood structure will be left intact. We will convert and substantially remove the lignin and dissolve the hemicelluloses. This is the first essential step in making this new wood product. The chemical digestion processes are altered to allow delignification without disintegration of the wood, that system being generally chosen which will allow greatest strength in the final product. The sulphate or "Kraft" system of digestion, which is the process used in making the high-strength paper usually found in bags, wrappings, paper tape, and corrugated or solid-fiber containers, has been found quite satisfactory. It is possible that the Mitscherlich or other processes may result in even higher strength values on certain woods, and that for decorative values some digestion systems allowing lighter final colors with additional bleaching may be found advantageous.

After the digestion, the veneers are carefully washed with water. When mechanical values only are desired, it is unnecessary to delignify the wood completely, for it has been found that, if digestion is arrested while there is still a certain percentage of lignin remaining, the resulting product is stronger. Comparing the making of paper to the preparation of veneers for impregnation, Table 1 lists the operations necessary and shows the simplicity of the veneer process.

TABLE 1 OPERATIONS PRIOR TO IMPREGNATION

Paper	Wood
Chipping the logs	Cutting veneers
Digestion	Digestion
Washing	Washing
Screening	Drying (not always necessary)
Beating (hydration)	
Forming the paper	

Delignified wood veneers, prior to any impregnation, show considerably changed characteristics from the original wood. Due to conversion and/or removal of lignin, they become far less brittle, and thin sections are quite flexible. They are, of course, softer, absorbing large amounts of water quickly with much swelling. Flexural strengths are severely reduced, but tensile strength and toughness factor are very greatly increased. These results appear sensible when reasons are evaluated. Removal of the cementing lignin adhesive between the cells naturally reduces the stiffness of the structure. The long thin cells have much of the considerable flexibility of other cellulosic fibers after the encrusting materials are removed.

The higher tensile values may be explained by two phenomena, namely, (1) the remaining material contains a much

Contributed by the Wood Industries Division and presented at the Aviation Division Meeting of The American Society of Mechanical Engineers, University of California, Los Angeles, Calif., June 5–9, 1944.

higher percentage of fibrous cellulose which is the one material in the natural wood having the highest tensile strength, and (2) there is a very good possibility that when an alkaline digestion such as the sulphate process is used, and considering the lower temperatures in the veneer digestion system, there might be a mild mercerization effect which is known to exert a great influence upon the tensile strength of cellulosic fibers.

POSSIBLE IMPREGNATING MATERIALS

The delignified wood is ready for the second step of the process, impregnation of the veneers. We have a wide choice of materials, both natural and synthetic, which may be added to the wood structure. We may now replace the unstable materials with stable ones, the weak materials with strong ones. The impregnant might be a monomer to be polymerized within the wood, or a solution of some resinous material. It might even be converted, more stable lignin. The most natural choice falls to the polar materials which have proved their value on natural wood, such as phenol-formaldehyde resins. The following remarks will be confined to the use of this type, which is available in many varying forms for impregnation purposes.

There is a considerable difference between the process of impregnation as used on natural woods and that used on delignified woods. The act of chemical digestion on the latter has opened up the structure and made it much more pervious. We find that instead of using any presteaming, steeping, soaking, or vacuum and pressure steps, it is only necessary to immerse delignified veneers in the resin bath for a few minutes. The time of soaking will vary, depending upon the thickness of the veneers, the wood species, the concentration and viscosity of the solution, final resin content desired, and other factors. As an example, a digested $^1/_{32}$-in. birch veneer, soaked 15 min in a water-soluble phenolic bath of 50 per cent solids content resulted in a resin solids content of 30 per cent in the final dry weight; when soaked for 30 min a 45 per cent resin content resulted.

It is generally granted that when impregnating untreated wood if the highest degree of dimensional stability is desired, it is necessary to use a resin of low polymerization so as to allow the smaller molecules to enter into intimate relation with the cellulose. These low polymers generally result in poorer impact and lower mechanical strength than the higher polymers, which tend to show better impact, higher strength, but less stability. There is some evidence to show that the cellulosic structure may be so altered by certain digestion procedures that the higher polymers may be used to impregnate delignified wood and will obtain both good physical values and dimensional stability at the same time.

RESULTING CHARACTERISTICS

Following impregnation, the veneers are treated as in natural wood impregnation and stacked wet to allow diffusion of the resin into the cell walls. They may then be dried and are ready for fabrication. Regulation of the drying operation will permit of varying degrees of "precure" controlling the polymerization of the impregnated resin. If slowly dried at lower temperatures, the veneers will be extremely pliable; thin pieces of some woods approaching the flexibility of leather. In this form the wood may be bent around very small radii without lifting the fibers; it is resistant to splitting, is very tough, and has little springback on bending. Several experienced wood technicians have scarcely believed that these pliable forms were really wood upon demonstration of their flexibility.

In this pliable type, we find a material which is useful for fabrication entailing sharp bends and complex shapes, and which can be held in position with minimum trouble until pressure is applied. Pressures as low as 25 psi have secured good bonds. The amount of compression and resulting physicals will depend on the specific pressures used, it being possible to get high densification of this softer type at pressures as low as 250 psi. Generally speaking these easily compressible forms will bond to each other or to natural wood veneers if given a fairly high resin content.

At the other extreme; woods resulting from higher-temperature precures give to the weight-conscious engineer a wood which has both low specific gravity and good stability. Here we approach the aim of wood improvement, to overcome the inherent weakness of wood, that of dimensional instability under moisture changes without increasing the density. This sounds like a contradiction, that one can add resin to wood and make it lighter, but is explained by several reasons. Delignification removes considerable quantities of lignin and the alkali-soluble hemicelluloses. These materials have a fairly high specific gravity. They are replaced by a resin of low density.

Beyond these facts lies the most important reason for the low-density results, that of the swelling of the wood structure in the impregnated condition. This swelling, above the volume of the original wood, may be caused by several factors, i.e., (1) removal of the confining sheath of lignin around each cell, allowing the cellulosic fibers to expand, (2) the mercerization effect, (3) the extra swelling caused by phenol-formaldehyde. An added cause might be the precuring of the impregnated veneers while still wet. Under proper controls, polymerization of the resin may be accomplished to some degree before the wood has a chance to shrink from loss of solvent, and thus will be "set" in a swollen low-density condition.

In this low-density "Impreg" there are many empty spaces, as the cell cavities have neither been filled with resin nor compressed flat. Therefore, water may be "taken up," and small increases of weight will show if wood is soaked in water, but if true impregnation of the cell wall has been secured, this water will be "free water" and not absorbed into the wood. A check of swelling rather than weight will lead to the proper conclusions. This low-density type is, of course, much stiffer and will not allow small-radii bends as will the pliable type. It is particularly suited to the making of low-density panels, and as a lightweight but moisture-stable facing.

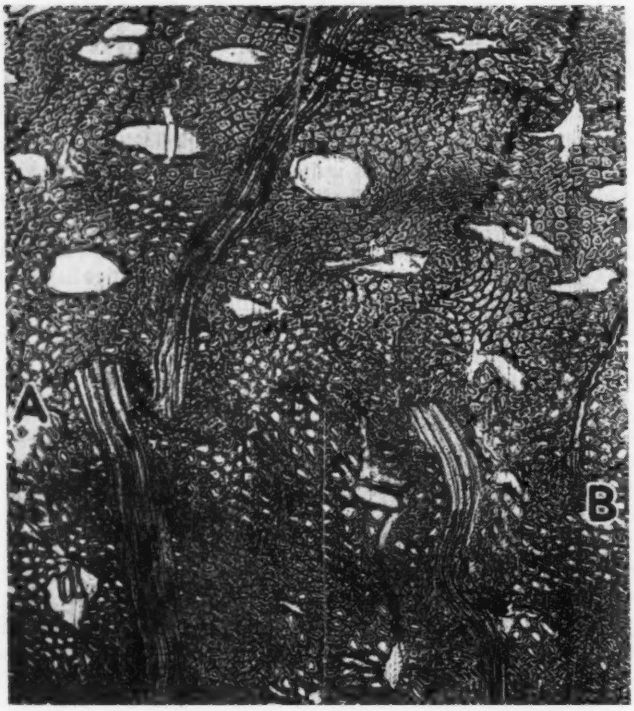
It must be remembered that these different types, whether pliable, stiff, or intermediate, are not the final cured material but only the raw stock from which articles are fabricated. In fact, the pliable type of impregnated wood may give an end product of fairly low density if low pressures are used during cure. Naturally all types are set by heat, sufficient pressure being necessary to bond the layers properly and give smooth surfaces. The final products are hard, infusible, stable combinations of good strength, with exceptional weight-strength ratios. Laminates of this product containing up to 40 per cent resin may be secured at no weight increase over the original natural wood, and the effect of the resin-cellulose combination upon strength characteristics is obvious.

MOST WOODS MAY BE TREATED

Veneers of many wood species have been experimentally treated and, although some have seemed to be more suitable than others, most woods can be successfully digested and resin-impregnated. Those especially successful in securing very pliable forms are birch and mahogany; the woods appearing suitable for low-density types seem to be spruce, western hemlock, and Douglas fir. Thickness of the veneers is important, for uniform digestions are practically impossible on thick sections, and the leaching out of the converted matter is very slow in the rinse. Digestions have been made on $^1/_8$-in. veneers, but $^1/_{16}$-in. or thinner are preferred. Good results have been obtained on both rotary-cut and sliced veneers, the former giving the most pliable forms in hardwoods.

It is evident that the one great objection to wood (swelling-shrinkage) is largely overcome without weight increase. Fabrication has been made easier. The many nonuniform qualities of natural wood, such as the number of rings per inch, the den-

(*Continued on page 657*)



(a)

(b)

FIG. 1 TRANSVERSE SECTIONS OF HIGH-DENSITY PLYWOOD: SUGAR MAPLE; ×95
(a, Showing overlapping ends of wood rays, and irregular bonding line from A to B. b, Showing zone of maximum distortion of tissues. Note dark horizontal line at C; this is a collapsed vessel surrounded by fibers whose original configuration appears to have changed.)

The MICROSTRUCTURE *of* HIGH-DENSITY PLYWOOD[1]

By WILLIAM M. HARLOW

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HIGH-DENSITY plywood (commonly known as "compreg") is a relatively new product fabricated from sheets of wood veneer. The veneer sheets are first impregnated with a low-polymerization phenol-formaldehyde resin (15 to 20 per cent) after which they are placed in a hot press and for about 1 hr are subjected to a pressure of 2800 psi at a temperature of 300 F. The resulting product is extremely hard and heavy (sinks in water) and possesses an almost flinty consistency.

SOFTENING TECHNIQUE

Anyone who has ever run a sharp-edged cutting tool across the end of a piece of high-density plywood will agree that it is not an ideal material for sectioning with a microtome. Even casual inspection indicated that the usual methods of softening wood were probably of little value.

Since Jeffrey's method[2] of softening in a dentist's vulcanizer has been used successfully on other refractory materials, samples of compreg were submitted to this treatment followed by a 1-week immersion in 40 per cent hydrofluoric acid. During the initial 3 hr in the vulcanizer, the samples swelled to about $1^1/_3$ times their dry size, the swelling taking place in the reverse direction to that of the original compression. After the acid treatment, it was possible to make microtome sections but these were very poor. The wood gave signs of having been maltreated in the vulcanizer. Although the resin-bonding agent appeared to have disintegrated somewhat, the material in general still cut with a stonelike grating sound and nicks developed almost immediately in the microtome knife. There was little evidence of delamination of the sample block.

A 30 per cent aqueous solution of urea was prepared, and "compreg" samples were refluxed in it for two hours.[3] Very little if any softening effect was evident when the blocks were tested with a razor blade. Possibly longer immersion might pro-

[1] The problem of working out a softening method for this material was suggested by Dr. H. P. Brown, Head of Department of Wood Technology, N. Y. State College of Forestry. Materials from several commercial sources and general data on manufacture were furnished by Mr. Joseph Gurvitch of the Engineering and Research Corporation, Riverdale, Md.

Contributed by the Wood Industries Division of The American Society of Mechanical Engineers.

[2] "Improved Method of Softening Hard Tissues," by E. C. Jeffrey, *Botanical Gazette*, vol. 86, 1928, pp. 456–458.

[3] Care should be taken that the condenser is not kept too cold, since a stoppage at the lower end may result followed by an explosion if there is no other way of allowing for expansion.

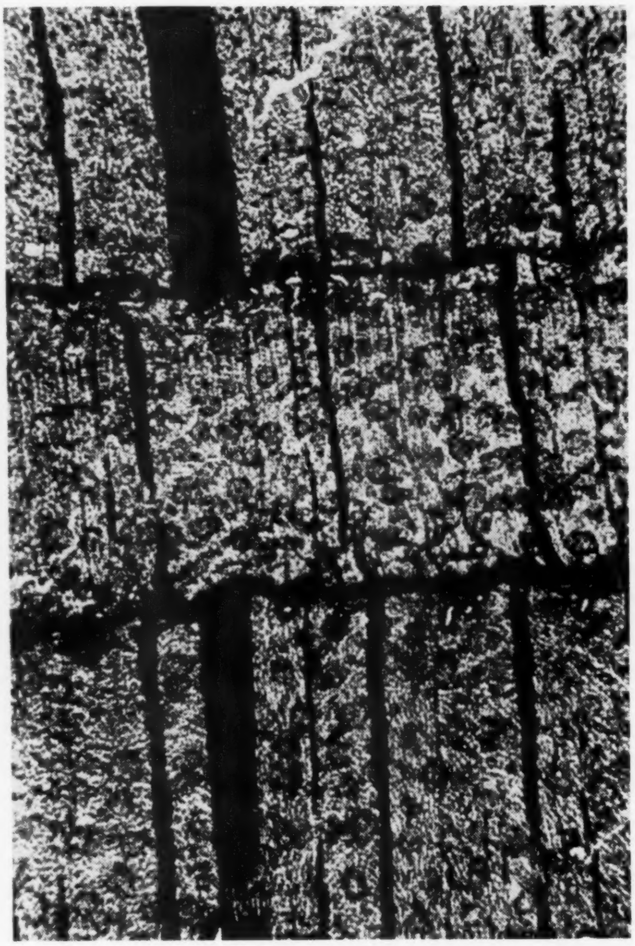

FIG. 2 TRANSVERSE SECTION OF GERMAN PROPELLER BLADE; PREPARED BY SANDING AND HAND-POLISHING; ×50

duce some softening, but the longer the treatment in any aqueous solution, the greater the swelling which may be anticipated.

Refluxing in a saturated solution of sodium hydroxide in 95 per cent alcohol produced no detectable softening after 3 hr immersion.

Refluxing for 2 hr in a 10 per cent aqueous solution of sodium hydroxide, however, produced the desired results, and even though a certain amount of swelling occurred, it was not sufficient to spoil the material for subsequent study. If only one or two sections are needed, a shorter time suffices, and less swelling occurs. In either case only the outer portion of the block is affected and the hard core tends to restrict swelling. After thorough washing in running water, the blocks were sectioned, using 20 per cent alcohol as a lubricant. Staining was accomplished in a few minutes rather than after several hours, due to the increased adsorptive properties of the tissues, Figs. 1(*a*) and 1(*b*).

Fig 2 illustrates a transverse section of a portion of a German propeller blade. This section was prepared without using a microtome. The end surface was first sanded and then polished on a fine Belgian hone. A section approximately $^1/_{16}$ in. thick was then made with a fine band saw, and the polished side affixed (with Canada balsam) to a glass micro-object slide. After thorough drying in an oven, the sawed surface was carefully sanded (thus reducing the thickness of the section considerably) and finally polished on the hone. Portions of three different layers are shown separated by the glue lines which appear black. The vessels, appearing near the bottom of Fig. 2, seem to be empty, but they are actually filled with the translucent yellowish resin. Those above (in the same layer) by contrast were unfilled until sanding occluded them with fine dust.

MICROSTRUCTURE

Although different samples show a certain amount of variation between one layer and the next, in general there appear to be alternating zones (1) of maximum impregnation and (2) of maximum compression indicated by tissue distortion. Zone (1) is directly along and immediately adjacent to the bonding line, while zone (2) is at a varying distance behind the first. Fig. 1(*a*) shows most of the vessels filled with the resin and not entirely collapsed, while in Fig. 1(*b*), by contrast, many of the vessels are more or less flattened and the rays show a serpentlike curvature indicating that a considerable amount of compression had taken place. However, in some samples nearly all vessels regardless of position are flattened.

Both figures also show a peculiar spiral configuration of the fibers around certain of the flattened vessels. This would seem to indicate that some side slipping may take place under pressure.

Probably the most interesting fact is that the ends of the wood rays are more or less rigid and serve to dovetail adjacent layers of veneer together, in this way perhaps strengthening the bonds between them.

SUMMARY

1 High-density plywood can be successfully sectioned by pretreatment in hot aqueous 10 per cent sodium hydroxide.

2 Penetration of the resin is quite variable as between different samples.

2 Usually the zone of greatest penetration is along the original surfaces of the veneer sheet.

4 In such cases, the greatest compression occurs near the center of the sheet.

Delignified Impregnated Wood

(*Continued from page 655*)

sity, proportion of late wood to early wood, variations in grain, all these are to a large extent nullified as we go further away from the natural product by delignification and approach a much more uniform material through the introduction of a known adhesive filler. Thus a new more reliable material is born, with a cellulose filler of natural fiber orientation and a binder of high strength and stable quality.

COST OF PROCESSING

The economics of this material is easily understood when the low cost of Kraft paper is considered. Since Kraft paper, with its many operations, produces a low-cost item, the base material used in the veneer digestion with its fewer operations should be still cheaper as well as having the fibers perfectly orientated. In comparison, the wood treatment includes veneering, digestion, rinsing, and drying; the papermaker must chip, digest, wash, screen, beat, and then reform the material into sheets on very expensive equipment. Impregnation of the delignified veneers is easy and cheap, the resin costs being the main factor. It appears evident that this material should be produced at a cost well below that of impregnated paper stock.

This discussion only touched on one impregnating treatment. There are many other materials which may be used with the treated wood, and much work remains to be done. It is possible to look forward to a whole group of end products both thermoplastic and thermosetting, based upon delignified wood, for strength, for stability, and—postwar—for beauty.

VISUAL-AIDS PROGRAM

Of the U. S. Office of Education

By GEORGE H. GRIFFITHS

REGIONAL DIRECTOR, VISUAL AIDS FOR WAR TRAINING, U. S. OFFICE OF EDUCATION, NEW YORK, N. Y.

Acting on an authorization of Congress, the vocational schools of the nation, on July 1, 1940, launched a program to train workers for defense industries. As the war situation grew more serious, the U. S. Commissioner of Education, John W. Studebaker, saw the necessity of accelerating this defense training. It was his belief that films designed for specific training situations could help materially to meet this need. As a result, under Congressional authorization to purchase materials for visual education, some funds for defense training were employed to produce an initial program of 48 training films. Of these, 18 were available for use two weeks before Pearl Harbor. The remaining 30 were released over a period of the next several months. Of this initial program of 48 films, 38 were for use in machine-shop training and ten were designed for the training of shipyard workers.

This initial program was largely experimental and called for the devising of a new type of instructional motion picture. Films had long been used with considerable success in the teaching of such subjects as the physical, biological, and social sciences; but little was known of their effectiveness in teaching manual skills. It was believed, however, that the learning of skills is largely an imitative procedure and that if, through the medium of the film, trainees could observe the detailed performances of expert craftsmen, learning would take place with increased speed. A further reason for belief in the suitability of films was, of course, the fact that the defense training program called for the instruction of large groups. This situation lessened the effectiveness of the customary shop demonstrations. The camera, however, could place before large numbers what otherwise would be visible to only a handful of observers at best. There were expectations of greater efficiency and effectiveness in other respects as well, but a detailed analysis of the contribution of the film medium would be somewhat aside from our present purpose, which is simply to indicate one or two of the basic hypotheses which guided the initial program.

The experiment worked. Indeed, so widespread was the endorsement received and so large the demand for further production that direct Congressional appropriations were granted for continuing expansion. In 1942, funds were provided for approximately 150 additional films. In 1943, a further appropriation underwrote the production of approximately 300 more. Altogether some 500 films have been authorized to date.

RESULTS WITH FILMS BASED ON INDUSTRIAL SKILLS

As already indicated, the initial program was concerned exclusively with films on industrial skills, and this emphasis has remained central throughout the subsequent expansion. Of the total number of films completed, in production, or planned thus far, over half are aimed at three major areas of industrial activity—machine-shop work with 132 films, aircraft fabrication and maintenance with 78, and shipbuilding with 43. At the same time there has been an increasing diversity in the over-all program, which now includes films in all of the following areas: precision wood machining, electrical work, foundry practice, supervisory training, nursing, refrigeration service, farm work, welding, plastics processing, optical craftsmanship, automotive mechanics, accessory assembly, bus operation, and safety practice.

Of this total program, 100 films are at present on the market, 100 more are virtually ready for release, 200 are 50–75 per cent completed, and the remaining 100 are just now going into production.

Of the 100 films available at present, many of which have been on the market only a comparatively short time, some 30,000 prints are now in use. Roughly one third of these, about 10,000 prints, have gone to the armed forces, another third are in use in industry, and another third have been purchased by the schools. In addition to this domestic distribution, prints have been acquired by over a dozen foreign countries, and in some cases films are available with foreign-language sound tracks. The total audience reached has been estimated as being in excess of 15,000,000.

Those of you who may be familiar with the scale of film use in the past will, I believe, appreciate that these figures represent a tremendous increase in the acceptance of the instructional-film idea. But along with this mention of distribution statistics, the question naturally arises: To what extent have these films accomplished their purpose? How effective have they actually been? On that score, it may as well be admitted that except for a few controlled experiments here and there we have few data of a genuinely scientific kind. I do not mean that we are wholly in the dark as to what films are accomplishing. It is simply that as yet we do not have rigorously accurate quantitative measurements of their relative effectiveness. We cannot, that is, determine the efficiency of a film as you would, say, that of a steam engine. Nevertheless, we do have indices that are broadly significant. For one thing there have been innumerable endorsements from training directors whose estimates of the acceleration accomplished by the use of films run from 25 to 50 per cent and who testify to qualitative as well as quantitative gains. Also, the volume of requests for continued and expanded production reveal that, to a reassuring degree, those who have tried films think well enough of them to want more. In addition, the sales figures to date demonstrate that these films have been considered worth buying to the extent of some 30,000 prints. In this connection, it should be emphasized that distribution is by sale only. There are no complimentary prints. Moreover, sales prices, which originally covered actual print costs and distribution costs only, have recently been placed on a basis intended to amortize the costs of production.

All in all, it appears evident that the idea which lay behind the program has proved to be sound. And, by way of clarifying that guiding idea more adequately, it should be said that these films have in all cases been conceived as aids *to* instruction. They are not intended to carry the entire teaching burden. They are one type of tool among and along with others. To be effective tools, they must be kept sharp. And films are sharp tools when they endeavor to handle not the entire job of instruction but those portions of it which require the direct visualization of processes, procedures, and dynamic relationships. They can present, that is, the phenomena and

Contributed by the Committee on Education and Training for the Industries and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

In presenting this paper the author showed one of the films, "The Slide Rule."—Editor.

activities that are the subjects of instruction and about which learning is required. In short, one of the essential aims of films is to reveal clearly what is being talked about. Usually a great deal more has to be said on even a limited topic than any film has room for, but much of what needs to be added will still be about what the film has shown.

It has been convenient, thus far, to refer to the U. S. Office of Education productions simply as "films." Actually, the sound motion picture is in each case only one part of the total unit which also includes a silent filmstrip (or slide film) and an instructor's manual. The filmstrip is primarily a follow-up or reviewing device for class use. The manual is intended as an aid to the teacher in making effective use of both the motion picture and filmstrip. The complete package we call a visual-aids unit.

Just one more word about the program as a whole—a word regarding our mode of production. All films are made on contract by commercial producers to whom awards are made on the basis of competitive bids. Almost without exception these producers are in the relatively small-scale nontheatrical category. Supervision is carried on by a small professional staff in the employ of the Division of Visual Aids for War Training, U. S. Office of Education, the Division being headed by Floyde E. Brooker and being under the general supervision of C. F. Klinefelter, assistant to the Commissioner of Education. The staff itself is made up of technical specialists and what, for lack of a better term, we call visual-aids specialists. Both types of specialists have usually had considerable teaching experience as well as experience with motion-picture production and training in the respective subject-matter areas. In virtually all cases industries and vocational schools are indispensable allies in the film-production job. They provide the necessary locations, properties, and expert craftsmen as well as technical consultation and the benefit of their experience with training. The co-operation of producers, industry, and the schools is not only gratifying, it provides the only basis upon which a program of this kind can have any hope of realization.

VISUAL AIDS FOR ENGINEERING TEACHING

From what has been said thus far, it will be evident that the film program of the Division of Visual Aids has at all times been concerned primarily with training in industrial skills. About a year ago, however, the suggestion was made that we devote at least a part of our program to engineering subjects. Why not make some films that would be useful in the ESMWT courses, for example? After a further study of this proposal in collaboration with various authorities, headed by John I. Yellott of the Illinois Institute of Technology, a decision was made to produce an experimental group of ten films: one on the slide rule, four on electronics, one on X-ray inspection methods, one on measurement with light waves, and three on the heat-treatment of steel. To this initial group of films, several of which have already been completed, a number of additional subjects have recently been added and are now in process of production. The new subjects include: a second film on the slide rule, three more on electronics, five on the fundamentals of mechanics, one on tension testing, one on flue-gas analysis, two on powder metallurgy, two on the heat-treatment of aluminum, one on refrigeration, two on lubrication, three on wood technology, and one on the use of the transit.

Needless to say, this venture into the general field of engineering has brought with it a host of special problems affecting our entire production procedure. For one thing it is evident that the essence of what enters into operating a lathe, for example, is directly visible and lends itself to meaningful live-action photography. But when the subject at hand is X rays, or light-wave interference, or electronics, for example, the essence of what is involved, from an engineering point of view, quite obviously eludes human vision. In short, we have found ourselves in an area where the task is one of providing visual aids on the invisible. I do not mean that that implies a contradiction or a mistaken endeavor. On the contrary, many would claim that it is precisely in such areas that instructional films meet their greatest challenge and in which they can make their greatest contribution. Producing such films does, however, call for a different approach. It means, for example, that there must be a heavy reliance on animation rather than actual photography, since animation, while graphic in nature, is itself a symbolic language capable of representing invisible phenomena and capable of many different levels of abstraction. It means a constant critical selection of those aspects of the total material to be covered which will benefit most directly from visual treatment. In that connection, one of our most frequent problems is that of determining to what extent the film should include graphs and mathematical formulas. Obviously, the language of mathematics constitutes a very large part of the engineer's concern. But while that language is a means of dealing with physical existences and motions, it is not itself a physical existence nor is it dynamic. The laws of motion are not in motion. Yet motion is of the very essence of the film medium. Static material, or material which can be studied adequately in static form, is seldom directly appropriate in a medium intrinsically dynamic. This theme cannot be more than touched upon here, but perhaps the nature of the problem has been at least partially suggested.

Perhaps a better way of stating the case is to say that the production of films in engineering is itself an engineering problem. It is a problem requiring a precise definition of the need to be met in each case and one requiring that the best means of meeting the need be very carefully determined. At the very outset of our approach to a proposed engineering film, for example, we have to ask: What will be the level of the students to whom the film is addressed? What background will they bring to it? What degree of specialization is aimed at in the instruction? What are the specific training difficulties ordinarily encountered? To what extent do difficulties arise from an inability to grasp the nature of the physical properties and processes involved? To what extent do difficulties arise from an inability to handle the mathematical symbolism involved? To what extent is there a failure to grasp the relationship between the symbolic language of mathematics and the physical processes to which it refers? What other instructional tools will be used along with the film, such as actual experiments, charts, and models? All these and numerous other questions regarding the teaching situation must be answered at least in part if the film is to be planned intelligently.

When the nature of the need has been analyzed that is still only a beginning. There must then be rigorous research on the authenticity of the data to be included in the film presentation. There must be an analysis of various possible film techniques. And there must be a regard for the purely practical side of production.

The problem of what to show and how to show it is often far from easy. Textbooks are far from adequate on many points. Words can frequently leave the most important things unsaid. We can say, for example, that monochromatic light waves will cancel out when they are out of phase by one-half wave length. But, as a phenomenon to be visualized, precisely how does that cancellation take place, and what happens to the energy of the component waves? As long as we are dealing with the matter verbally, such questions need not arise. But on a screen, something has to be happening which is a reasonably faithful account of a concrete natural phenomenon. Again, we can say that a reversal of phase takes place when light is reflected at the point of meeting between a more dense and a less dense medium. But just what happens in detail? Doubtless there are many experts who know the answer, but

(*Continued on page 662*)

The NAVY TRAINING-FILM PRODUCTION PROGRAM

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SINCE Pearl Harbor, the United States Navy has been faced with the dual responsibility of preparing to fight a war and of fighting the same war. In consideration of the amphibious nature of the conflict and the extent of the fields of operation, the scope of the task need not be elaborated.

The training of personnel has been a major part of the task. Consider the problem of training not hundreds, not thousands, but millions of officers and men adequately and quickly. Most of the enlisted trainees have never been aboard a ship. Only a few have had previous military training. Their previous technical education is limited primarily to that provided by the public high school.

Consider also the maintenance and operation of battleships, carriers, patrol boats, and submarines, the maintenance of airplanes and lighter-than-air craft, the handling or control of arms from the automatic pistol to the 16-in. gun, the overhaul and repair of motors, turbines, and gasoline Diesel engines.

The extent of the training problem can be conceived in part when it is realized that modern naval warfare demands efficient personnel performance in the control, maintenance, and repair of every device that the American engineer has been able to contribute.

In recognition of the tremendous scope of the problem and of the fundamental importance of the training program to final victory, the Navy enlisted the latest and best in training techniques and procedures. Among the other techniques adopted to speed the training process and to insure exact personnel performance has been the training film.

It is the purpose of this paper to offer in summary a discussion of the training-film production program of the Navy. Not all the aspects of production can be presented. Because many questions have been asked about the program, the paper is organized as a series of questions and answers, emphasizing those aspects which are likely to be of greatest interest to engineers.

WHAT ACTIVITY IS CHARGED WITH THE RESPONSIBILITY OF PRODUCING TRAINING FILMS FOR THE NAVY?

The Bureau of Aeronautics is charged with responsibility of the procurement, the production, the cataloguing, and the distribution of training films for the United States Navy. To implement this responsibility the Bureau established the Training Film Branch. The Branch is divided into four sections, each with well-defined responsibilities.

The Project Supervision Section is directly responsible for production. To fulfill its responsibility the section maintains liaison with requesting authorities and with commercial organizations under contract with the Navy for the technical aspects of production. This section appoints production specialists who are responsible for following the development of every request from the original conferences and research to the completed training film.

The Procurement Section is responsible for all contractual arrangements with commercial writers and production organizations, as well as for similar arrangements for the processing of prints and negatives.

The Distribution Section is responsible for the ordering, storing, and shipping of prints of films to the entire naval establishment. The extent of this activity will be discussed later.

The Cataloguing and Evaluation Section is responsible for the maintenance of production records, including records and reviews of films produced by other agencies. This section maintains records of production progress and status so that a detailed up-to-the-minute report on all or any part of production can be obtained within a few hours. This section is responsible also for compiling and printing the Navy Training Film Catalogue and Supplements.

WHAT IS THE EXTENT OF TRAINING-FILM PRODUCTION?

Since July, 1942, the Navy has produced about 3000 training motion pictures and slide films. Approximately 900 more are in production at the present time. About one half of these are slide films and the other half are motion pictures.

Each new subject is studied individually and the entire range of motion-picture or slide-film experience is considered during the initiation of production. Color is used when it will clarify the subject. Animation, models, stop motion, slow motion, the split screen, and many other devices have been employed successfully.

New subjects are being requested and new films are being released at the rate of about 25 per week.

WHAT SUBJECT MATTER HAS BEEN PRESENTED IN TRAINING FILMS?

The subjects presented in Navy training films cover an area as broad as the field of training.

For instance, in the field of aviation, the training of pilots has been presented from the basics of flying through the flight characteristics of the various aircraft, through acrobatics, to combat tactics.

Films for the Bureau of Medicine and Surgery extend from first aid and personal hygiene to the technique of the construction of dental plates and the fight against malaria.

Films on the subject of ships range from the identification of ships to shipbuilding skills, to loading and unloading, damage control, navigation and combat tactics.

Training films on communication extend from flag signaling to the most advanced developments in the field of radar.

Films for the orientation of personnel range from the procedure in reporting to a new station to the geography and anthropology of the Islands of the South Pacific.

Hardly an area exists in which the training film has not made direct contributions, from the training of the lowliest "boot" to the co-ordination of the activities of the admirals.

WHAT IS THE EXTENT OF THE DISTRIBUTION OF TRAINING FILMS?

Since July, 1942, the Bureau of Aeronautics has distributed 350,000 16-mm motion-picture prints and 525,000 slide films of 35 mm. From July, 1942, to June, 1943, 117,000 motion-picture prints and 200,000 slide films were distributed while from July, 1943, to date, 235,000 motion pictures and 300,000 slide films have been distributed to Navy activities, an increase of about 100 per cent.

Contributed by the Committee on Education and Training for the Industries and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Films are shipped to over 100 district libraries all over the world to be redistributed to training stations or to ships. Every ship large enough to provide projection facilities is equipped or is to be equipped with a library of training films. Training stations, shore establishments, hospitals, and bases in foreign ports have libraries of their own or have films made accessible by district libraries. In a 12-month period enough film was requested and distributed to reach around the world approximately one and one-half times. Enough film was delivered to training activities during that year to keep a single projector running continuously for 9 years. Nearly 1000 Navy-produced subjects and more than 1000 subjects produced by other agencies are in distribution currently.

WHAT ARE THE CHECKS AGAINST DUPLICATION OF PRODUCTION AMONG THE VARIOUS ARMED SERVICES?

A request for production contains the following information:

(*a*) The general subject to be presented.

(*b*) The reason for the request, i.e., why a film on the subject is considered advisable and the contribution it is expected to make.

(*c*) The audience for which the picture is intended.

(*d*) The scope of the production, i.e., a brief outline delimiting the material to be presented.

(*e*) The name of the technical expert on the subject who has been assigned to the task of advising on technical facts.

(*f*) The security classification, i.e., whether the material to be presented is unclassified, restricted, confidential, or secret.

(*g*) The priority desired, i.e., the importance of the production to the war effort.

(*h*) The names and designation numbers of films on the same or related subjects.

Before the request reaches the Bureau of Aeronautics, it has been routed through the Bureau of Naval Personnel which is cognizant of general training or through the Office of the Deputy Chief of Naval Operations for Air, which is cognizant of aviation training. (Certain other phases of training are directly under the Office of the Secretary or the Office of the Commander in Chief.) If there is actual duplication, the request is stopped at one of those points. If there is evidence of apparent or possible duplication the attention of the Bureau of Aeronautics is called to the fact.

On reaching the Training Film Branch, a check is made through the Cataloguing and Evaluation Section to determine the nature and scope of existing films that relate to the same subject. Films from the other services of the United States as well as those by other members of the United Nations group are reviewed.

It has been estimated that duplication has occurred in less than 0.5 of one per cent of the cases.

WHAT CHECKS ON THE TEACHING QUALITY OF NAVY TRAINING FILMS ARE MADE DURING PRODUCTION?

Three specialists are particularly responsible for the effectiveness of the training film as a teaching device:

1 The technical advisor named by the requesting agency is an expert on the information to be presented. He is thoroughly acquainted with the facts to be taught.

2 The Training Film Branch selects an educational consultant who has the responsibility of organizing the facts in consideration of the personnel to be taught. He must know who is to be taught. He must know the experience of the personnel and their educational background. He must see that the material is organized into comprehensible units for designated trainees.

3 The Training Film Branch also appoints a project supervisor. The project supervisor is the Navy producer. On him rests the responsibility for considering the subject matter in terms of visualization.

These three specialists co-operate to plan the presentation of the material for submission to a script writer.

Available to the technical advisor, the educational consultant, and the project supervisor are specialists in graphics, in layout, design, animation, and in other phases of motion- and still-picture production.

Three standards of excellence are maintained for the production of Navy training films:

1 They must be technically correct as to subject matter.

2 They must adhere to sound psychological principles.

3 They must be acceptable examples of the best in motion- or still-picture craftsmanship.

WHAT ARE THE EVIDENCES OF THE EFFECTIVENESS OF THE TRAINING FILMS AS A TEACHING DEVICE?

Late in 1942, the Bureau of Naval Personnel established the Training Aids Section. Now a division, that activity has been working in the field of utilization of training aids including training films. This work cannot be described in detail here. Briefly, the Training Aid Division has been responsible for the establishment of local and district film libraries. In addition, it has placed specialists in the utilization of visual aids in the training establishments. Further, it has co-operated with the Training Film Branch in the evaluation of training films, making general and specific suggestions for their improvement.

A similar activity under the Deputy Chief of Naval Operations for Air has provided the branch with reports on the effectiveness of films in the field of aviation and aeronautics.

It can be considered that the criticism offered by these two activities is open and frank. By and large, the reports indicate that films are being used widely and successfully, that they cut training time to a surprising degree, and that they are effective accurate training devices.

A second evidence of the effectiveness of the training films is indicated by the continual chain of requests for new productions that cross the desk of the head of the branch. The number of these has already been noted. Related to these are the requests for revisions of previous productions necessitated by changes in equipment and by the development of new techniques and new theories of operation.

A third evidence of the effectiveness of the training film is the increasing number of requests for distribution of prints and the constant pressure for increased speed in production. Not a day, and probably not an hour, goes by without some naval activity saying in effect, "Speed up production," and "Give us prints of completed films."

WHAT ARE THE IMPLICATIONS FOR TECHNOLOGICAL EDUCATION?

To the student, engineering training is a grueling experience of at least 4 years' duration. The first year provides a general introduction to engineering tools; mathematics, physics, chemistry, mechanical drawing. The second year provides additional tools and correlates those of the first year. The third and fourth years are packed with the application of engineering tools to general and special engineering problems.

The first 2 years are of utmost importance. Given a thorough background and understanding of the fundamental concepts, the advanced courses can be grasped in a satisfactory way. How many times the instructor of freshmen has asked the question, "Why were'nt these boys taught the fundamentals in secondary school?" The instructor of calculus has asked, "Why don't these fellows understand trigonometry?" The instructors of advance chemistry have criticized those of elementary chemistry.

In the opinion of the author such criticism, no matter how justified, is fruitless. It seems here that having applied the best available educational and psychological selection devices at entrance time, having received the lads as technological students, the problem becomes one of accepting the students as

they are and teaching them what they need to know in the best way and shortest time.

The training film can help. The training film not only can be applied to technology, but indeed it lends itself particularly to technological education. It can explain or assist in the explanation of any technological concept.

Recognizing the necessity for a thorough understanding of the elements of engineering, it can be said safely that the film can remove from the realm of undergraduate mystery such factors as mathematical concepts of equality, the resolution of forces acting simultaneously on a point, the lineal concept of forces, the theory of relationship of angles to area, the affinity of atoms in the formation of molecules, the theory of atomic and molecular weights, as well as the skill required in mechanical drafting.

A training-film production program is expensive, admittedly. Co-operative production might solve the expense problem. An organization such as this Society, dedicated to engineering and to engineering education, could take the leadership in organizing production among the engineering colleges of the United States assigning mathematics films to M.I.T. (for instance), light to California Tech, basic electricity to Stanford, sound to Rensselaer, chemistry to Brooklyn. A 5-year program of reciprocal production and distribution would pay untold dividends in better engineering in this country, contributing simultaneously to world understanding through the media of engineering-training films. Engineers speak the same language the world over; pictures are understood universally.

Effect of Shape on the Formability of Deep-Drawn Sheet-Metal Parts

(*Continued from page 648*)

to, or less than, the limiting value, it is inferred that the part can be made in one operation. Tooling and developmental costs may thus be reduced. Cost and time may be frequently reduced by redesigning parts that would require more than one operation to permit the forming to be done in a single operation.

SUMMARY

1 The effect of variations of thickness between 0.020 in. and 0.091 in. on the maximum-depth part that can be formed was found to be slight for the aluminum alloys.

2 The maximum value of the ratio h/d for a square or rectangular part depends almost entirely upon the ratio r/d. Within the range of sizes investigated, a single curve may be used to represent all such parts regardless of size.

3 The same curve may be applied to rectangular and triangular parts, within certain limitations, provided d is determined as the square root of the projected bottom area of the part. The main limitations are that (*a*) for triangular parts none of the internal angles between sides should be less than about 45 deg; and (*b*) for rectangular parts with a length greater than 3 times the width, d should be determined by Equation [5].

ACKNOWLEDGMENT

The authors wish to acknowledge the assistance of Mr. T. H. Hazlett who worked on the project in its early stages, and Mr. R. N. Christy who assisted in the experimental work.

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Visual-Aids Program

(*Continued from page 659*)

few of the standard texts are of any great help. On this very point I may say, parenthetically, that the checking we were forced to do for film purposes led to the discovery of an actual error in the account of light interference offered in some widely used texts and manuals, the presence of the error later being confirmed by high authorities in the field of optics. I mention these considerations merely by way of illustrative examples. Comparable examples could be cited from the case histories of virtually every film we undertake.

What I am anxious to point out in all this is that the accurate *visual* handling of a subject sometimes forces a more rigorous and painstaking analysis than is called for in verbal discussion. Merely by way of speculation, suppose that at the time when the Edison effect was first observed it had been necessary to describe it in other than verbal terms. Suppose it had been necessary to account for it visually in terms of what actually happens. Might the process of attempted visualization have started chains of thought which would have brought the development of electronics many years earlier? Obviously, there is no way of knowing, but the question is not without interest.

If the production of films in engineering is an engineering problem, it perhaps can be said that the same thing applies to education as a whole. But few, I believe, would claim that we approach it that way. An engineer, I take it, does not consider that he has done a job of engineering with a turbine, say, until the turbine does what it is designed to do. But all too frequently we feel that we have done a job of teaching even when few have *learned* what the course was designed to teach.

Films are one way of trying to make sure that there shall be genuine learning. Obviously, we haven't gone very far as yet. The systematized use of visual aids in instruction is still in its infancy. Many of us feel that we are far more aware of unanswered questions than we are of reliable conclusions. In engineering you have a backlog of codified knowledge based on principles experimentally verified. You have a history which, I assume, traces back at least as far as Archimedes. You have formulas long tested in empirical application. But we who work in instructional films are just beginning. There is ample evidence, of course, that in many fields instruction with films is more effective than instruction without them. But that is scarcely reason for an easy satisfaction. You engineers are not satisfied merely because an automobile, say, is faster than a horse and buggy. The challenge lies in what the automobile in terms of its own potentialities should achieve. Likewise with films.

Sealing AVIATION FUEL-SYSTEM EQUIPMENT

By T. R. THOREN

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SYNTHETIC-rubber seals have provided a convenient and satisfactory solution to the problem of sealing aviation fuel-system equipment. The introduction of aromatic blended aviation fuels, and the requirement that military aircraft be capable of satisfactory operation at temperatures down to —65 F have made it necessary to alter some of the seals both in the rubber composition and in design.

All manufacturers of aviation fuel-system equipment have gone through extensive programs of design and testing to evolve the seals which are now in production. This discussion will deal in detail with those developments with which the author has been directly connected, namely, fuel booster pumps, selector cocks, and engine-driven pumps.

FUEL SYSTEM

A typical fuel system, as shown diagrammatically in Fig. 1, includes the following:

Booster. The fuel booster pump is mounted directly on the bottom of the fuel tank. It is a centrifugal pump driven by an integral explosion-resistant electric motor at a speed of 6000 to 9000 rpm. Its functions are:

(*a*) Boosting (pumping) of fuel to the engine-driven fuel pump at high altitude to prevent fuel-system failure by reason of vapor lock.

(*b*) Fuel-system priming and pressuring incident to engine starting.

(*c*) Operation as an emergency fuel pump in high-pressure systems in the event the engine pump should become inoperative.

At low speed the discharge pressure is 6 to 10 psi, and at high speed the pressure is 12 to 22 psi, depending upon the setting of the rheostat or fixed resistor.

Selector. The purpose of the selector cock is to enable the pilot to select the tank from which he wishes to draw fuel. Each inlet port is connected to a separate tank-discharge line, and the outlet is connected to the line leading to the engine.

Strainer. The strainer contains a fine-mesh screen for collecting dirt and foreign material that gets into the fuel.

Engine-Driven Pump. This pump is mounted on the engine-accessory section and is driven at approximately crankshaft speed. It receives fuel under pressure from the booster pump and, if feeding a high-pressure carburetor, the pump will increase the pressure still higher to 17 psi which is now a common value. This pump is fitted with an integral balanced relief valve for delivering fuel at the proper pressure depending upon engine requirements at any moment.

Carburetor. The carburetor and nozzle for injection of fuel into the engine induction system are the last items in the liquid-fuel circuit.

BOOSTER PUMP SEALS

Centrifugal booster pumps must be mounted on the bottom of the tank as shown in Fig. 2, to achieve optimum inflow of fuel and ejection of vapor bubbles from the pump throat. In this position, a static fuel head is always imposed on the shaft seal between the pump and motor. This head may vary from a few inches to several feet. When the pump is running, its discharge pressure also acts on the shaft seal. Since the motor armature is carried on grease-lubricated ball bearings, it is essential that the seals keep all traces of gasoline and gasoline vapor out of the motor, otherwise the grease will be dissolved, and premature bearing failure will result. A seal drain chamber is provided, between pump and motor, which is vented overboard.

Gasoline within the motor is not a fire hazard because the unit is of explosion-resistant construction.

Fig. 3 shows a popular type of fuel booster used on bombers and some fighter aircraft.

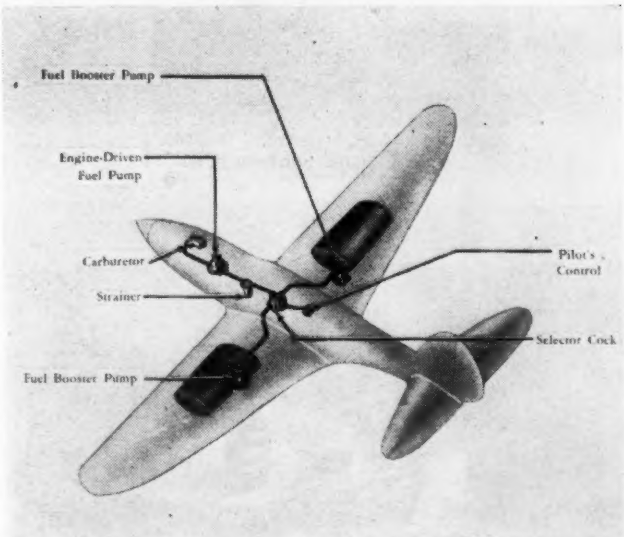


FIG. 1 AIRCRAFT FUEL SYSTEM

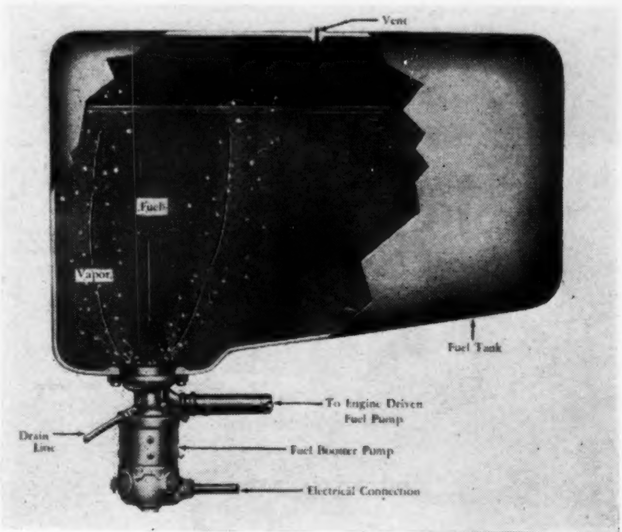


FIG. 2 INSTALLATION OF FUEL BOOSTER PUMP

Contributed by the Aviation, and Rubber and Plastics Divisions and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

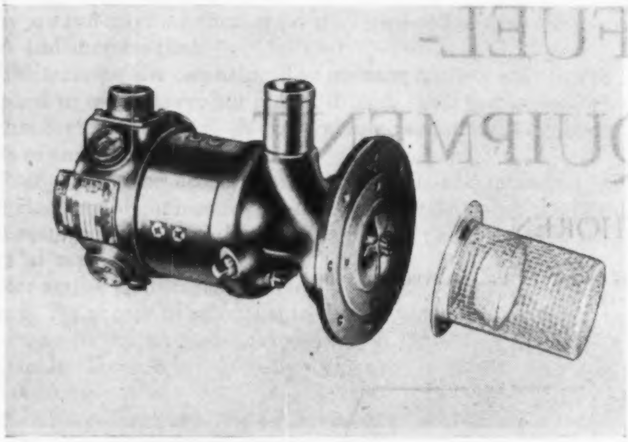


FIG. 3 FUEL BOOSTER PUMP

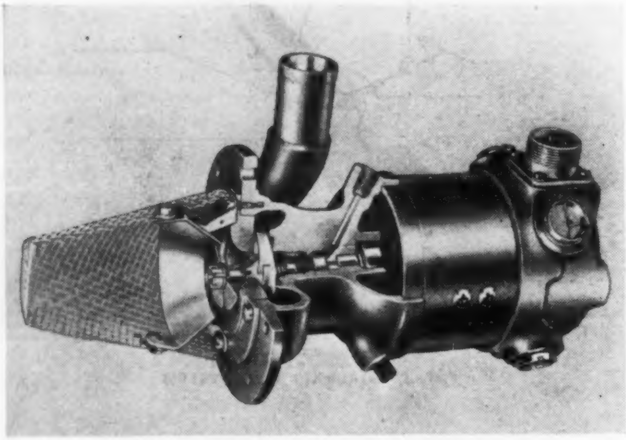


FIG. 4 SECTION THROUGH FUEL BOOSTER PUMP

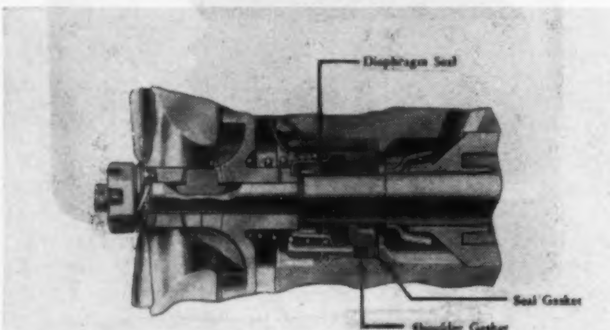


FIG. 5 SEAL DETAILS

Fig. 4 is a section through the pump and upper end of the motor.

Fig. 5 shows the detail of the shaft seal. In this design there are three synthetic-rubber parts, the rotating diaphragm seal, the upper and the lower stationary seal gaskets.

Diaphragm Seal. This part is of molded Perbunan. It is assembled around a carbon rotating seal and held in place by spinning down the open end of the metal seal cup. This provides a gasoline-tight joint at the periphery of the carbon. A snap ring holds the small diameter of the seal in forceful contact with the shaft.

This seal must satisfy two important requirements:

1 The material must be resistant to aromatic blended fuel having a composition by volume as shown in Table 1. The rubber must not swell excessively, become tacky and lose its strength, or shrink excessively upon drying out after being immersed in all types of aviation fuels for short or long periods of time.

TABLE 1 COMPOSITION OF AROMATIC TEST FUEL

60 per cent	65-octane aviation fuel
5 per cent	Benzene
15 per cent	Xylene
20 per cent	Toluene

TABLE 2 PHYSICAL PROPERTIES OF DIAPHRAGM MATERIAL

1400	psi tensile strength
35–45	Shore "A" durometer at room temperature
25	per cent swell or volume increase during 24 hr soaking in aromatic blended fuel
6	per cent shrinkage or volume reduction below original size, during drying in air at room temperature 24 hr following 24 hr soaking
1	per cent shrinkage during 24 hr soaking in 65-octane aviation fuel
	Good flexibility at —65 F, as determined by S.A.E.-A.S.T.M. bent-loop method

TABLE 3 PHYSICAL PROPERTIES OF GASKET MATERIAL

60–70	Shore "A" durometer
1000	psi tensile strength
25	per cent swell in 24 hr soaking in aromatic fuel
5	per cent shrinkage after drying 24 hr in air at room temperature following 24 hr soaking
1	per cent shrink during 24 hr in 65-octane aviation fuel
	Fair flexibility at —65 F

2 The material must retain a certain amount of resiliency at temperatures down to —65 F, not only when new but also after some of the plasticizer has been extracted by the various aviation fuels. Referring to Fig. 5, note the diaphragm or conical section of rubber between the shaft and outer diameter of the carbon. This section must be flexible so the seal spring can hold the carbon seal in gasoline-tight contact with the stationary seal whose face may not be perfectly square with the shaft because of the stack-up of manufacturing tolerances. All synthetic rubbers available today become stiff at low temperatures. Many are glass-hard at —30 F. A thin section of rubber improves the flexibility. In this case a thickness of 0.028 in. was found to be a good compromise to meet the performance specifications at —65 F with the rubber compound that was finally selected. The physical properties shown in Table 2 have given good results.

Soaking tests are always run on the actual part when available. Tensile strength, durometer, and flexibility are determined on a standard sample slab 0.068 to 0.075 in. thick.

Stationary Seal Gaskets. The stationary seal is a hardened steel part held in place by a threaded sleeve, as shown in Fig. 5, and sealed against leakage along the aluminum housing by means of the upper and lower seal gaskets.

The upper gasket is a Hycar compound molded as a tube on a mandrel, wrapped, then cured in an autoclave. The tube is ground to size on the outside diameter, and the individual parts sliced off in a lathe using a sharp tool.

Note that this part is almost completely confined in the assembly. It should be capable of deforming under the force of the threaded nut and completely fill the volume which is a variable due to manufacturing tolerances. The requirements of this application are not severe. Material having the properties shown in Table 3 does the job.

The lower gasket is sheet stock composed of granulated cork bonded together by aromatic resistant Buna rubber. The function of this gasket is to reduce distortion of the stationary-seal member due to the assembly pressure and to act as a second line of defense against fuel seepage along the housing.

SELECTOR COCK SEALS

Fig. 6 shows one type of conical-plug selector cock. The fuel is sealed in the desired channels by means of synthetic-rubber ring inserts around each port in the body, which makes surface contact with the rotatable metal cone.

The seals are individually molded of Perbunan, as shown in

TABLE 4 PHYSICAL PROPERTIES OF PORT SEAL

1000	psi tensile strength
65–75	Shore "A" durometer
12–15	per cent swell during 24 hr soaking in aromatic fuel
4	per cent shrinkage after drying 24 hr in air at room temperature following 24 hr soaking
1	per cent shrink during 24 hr in 65-octane aviation fuel
	Good flexibility at —65 F

Fig. 6. These are cemented in place. After oven-drying, the seals are ground in assembly to provide a true conical surface for the cone seat.

The rubber must meet the following requirements:

1 It must be hard enough to grind cleanly, and not form a wave ahead of the point of grinding-wheel contact.

2 Resiliency is required to prevent leakage when the cone is cocked eccentrically within the limits of reasonable machining tolerances. This requirement must be met at all operating temperatures down to —65 F.

3 Swelling in aromatic fuel must be low to avoid raising the cone to the point of interference with the lifter mechanism.

4 The material must have good resistance to abrasion.

The shaft seal consists of two materials as shown in Fig. 6. A fibrous commercial shaft packing is inserted down into a triangular recess. The synthetic-rubber washer is a snug fit on the shaft, and its outer periphery is in contact with the counterbore in the cover casting. The rubber is constantly under compressive stress produced by the seal spring acting on a metal washer. This seal has performed exceptionally well under all aircraft-operating conditions. The synthetic rubber is Perbunan having the following properties: 40–50 Shore "A" durometer; 1000 psi tensile strength; swelling, shrinkage, and low-temperature limits same as for gasket covered by Table 3.

ENGINE-DRIVEN PUMP SEALS

The function of this pump is to furnish to the carburetor the required quantity of fuel and maintain the pressure within fairly narrow limits. Fig. 7 shows one model of engine-driven pump.

The lower casting having the threaded boss is the pump assembly. The removable upper assembly contains the balanced relief valve, adjustment mechanism, and by-pass valve.

Fig. 8 is a cross-sectional view through the pump assembly to show the seal construction. Three parts made of or containing synthetics will be discussed, i.e., diaphragm seal, bearing gasket, and engine oil seal.

Diaphragm Seal. Note that this part is of the same general design as used in the centrifugal booster pump, Fig. 5. Also its function is the same; to prevent fuel leakage where the drive shaft passes out of the pump housing. The diaphragm has an internal bead at its large diameter which matches a groove in the rotating seal member. The metal seal cup, against which the spring rests, is a snug fit around the rubber and is not spun down at assembly. This seal can be completely disassembled for inspection. The material used in this diaphragm is Perbunan, having the same physical properties as the booster pump-diaphragm seal, tabulated in Table 2.

Bearing Gasket. This part is made of granulated cork bonded together with Neoprene. In the unconfined condition, the gasket is almost twice as long as shown in Fig. 8. As the threaded nut is screwed down to hold the several internal pump parts in metal-to-metal contact, the cork gasket is compressed to 60 per cent of its free volume. In so doing a gasoline-tight seal results between the pump-body bore, bearing, and stationary seal housing.

This application takes advantage of the great compressibility of cork and its resistance to excessive permanent set.

Swelling tests on unconfined samples in aromatic fuel have shown volume increases of 65 per cent. A substantial part of this swelling is due to the cork itself. After drying out there was a shrink of 20 per cent below the original volume. The

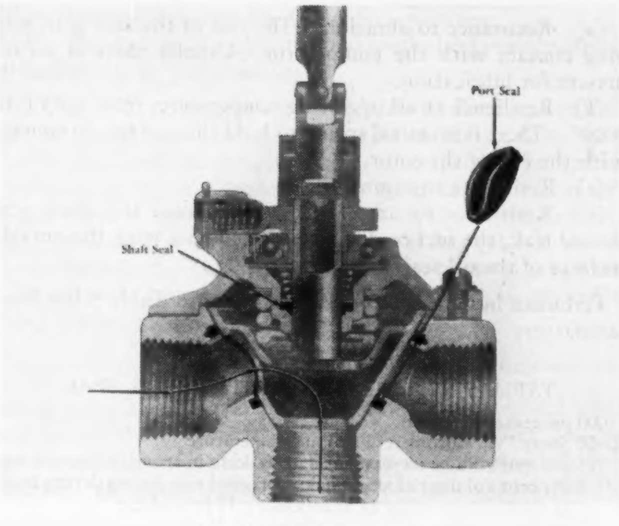


FIG. 6 SELECTOR COCK

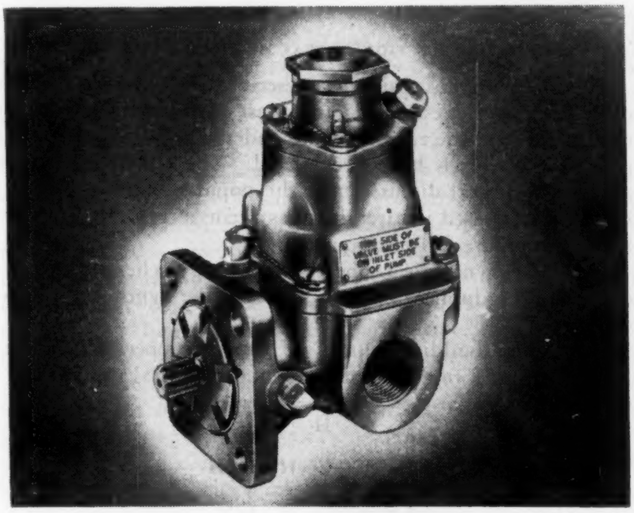


FIG. 7 ENGINE-DRIVEN PUMP

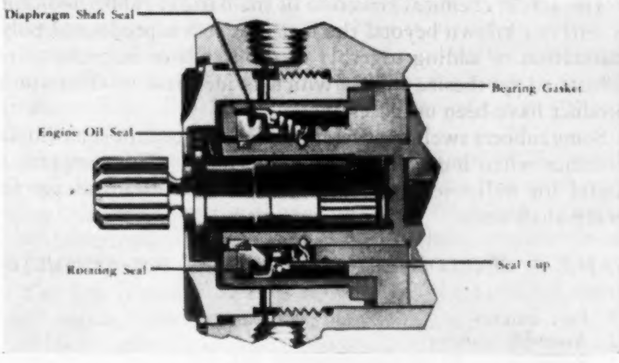


FIG. 8 SEAL SECTION

tendency to swell is an advantage in this application because it produces a still tighter seal. The shrinkage has not caused trouble, perhaps because, when confined, the 40 per cent initial compression more than counteracts the shrinkage.

The Shore durometer reading on this material at room temperature is 55–70.

Oil Seal. The function of this part is to keep oil mist in the engine accessory-drive pad from entering the pump-seal drain chamber. The design and material must satisfy the following requirements:

(*a*) Resistance to abrasion. The end of the seal is in rubbing contact with the pump rotor. Usually there is no oil present for lubrication.

(*b*) Resilience at all operating temperatures from —65 F to 200 F. There is no metal spring to hold the seal face in contact with the end of the rotor.

(*c*) Resistance to engine oil.

(*d*) Resistance to aromatic fuel. In case the shaft seal should leak, the fuel could come into contact with the outside surfaces of the oil seal.

Perbunan having the properties shown in Table 5 has been satisfactory.

TABLE 5 PHYSICAL PROPERTIES OF OIL SEAL

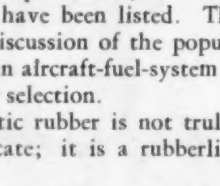
1000 psi tensile strength
70–80 Shore "A" durometer at room temperature
25 per cent volume increase in 24 hr soaking in aromatic blended fuel
5 per cent volume reduction below original size during drying in air at room temperature 24 hr following 24 hr soaking
15 per cent volume increase in mixture of 70 per cent aviation-engine oil and 30 per cent aromatic fuel during 24 hr soaking at 250 F
5 per cent volume reduction during drying

SELECTION OF SEAL MATERIALS

The foregoing discussion has described the duty which each of several synthetic-rubber parts must perform. The type of rubber meeting the requirements, and the applicable physical properties for each have been listed. The remainder of this paper is a general discussion of the popular varieties of synthetic rubbers used in aircraft-fuel-system accessories and outlines a procedure for selection.

Varieties. Synthetic rubber is not truly a chemically produced rubber duplicate; it is a rubberlike synthetic hydrocarbon.

The basic "building block" of *natural* rubber is isoprene. The structural formula for one unit of the natural rubber polymer is



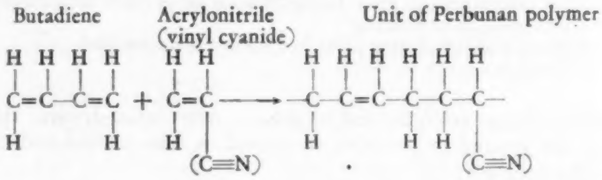
The actual chemical structure of the natural-rubber molecule is still not known beyond the fact that it is a product of polymerization or adding together of thousands of isoprene units. Efforts to synthesize rubber which is identical to the natural product have been unsuccessful.

Some rubbers swell to several hundred per cent of their initial volumes when immersed in aromatic fuels. This property is useful for bullet-sealing fuel tanks but is a disadvantage for pump-shaft seals.

TABLE 6 DEVELOPMENT SPECIFICATION FOR SYNTHETIC-RUBBER PART

1 Part number................. Name.......................
2 Assembly number...
3 Resistant to (40 per cent aromatic fuel, 100-octane and 65-octane fuel)
4 Service operating temperature range (—65 F to +168 F)
5 Volume increase of part during soaking 24 hr at room temperature in
   Aromatic fuel .... per cent max; 100 Octane .... per cent max; 65 Octane .... per cent max
6 Volume reduction of part, below original volume, on drying 48 hr at room temperature following 24-hr soak in the following:
   Aromatic fuel .... per cent max; 100 Octane ...... per cent max; 65 Octane .... per cent max
7 Shore "A" durometer .... to ....
8 Tensile strength .... psi min A.S.T.M. Spec..........
9 Elongation .... per cent min by A.S.T.M. Spec..........
10 Low-temperature flexibility A.S.T.M. Spec.......... or..........
11 Compression set at room temperature A.S.T.M. Spec..........

One of the most popular *synthetic* rubbers for fuel-system accessories is Perbunan. It is made by the copolymerization of Butadiene and acrylonitrile.



The Butadiene is produced from natural gas, refinery vapors, or from ethyl alcohol. Acrylonitrile is formed by the action of hydrocyanic acid on ethyl alcohol.

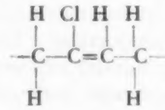
A mixture containing 60 to 80 per cent Butadiene and the remainder acrylonitrile is emulsified in water using various soaps as the emulsifying agent (1 per cent or less). Small amounts of other materials, accelerators, and inhibitors are added to control the reaction. As polymerization proceeds under controlled conditions, long chains made up of Perbunan polymer units are formed in the emulsion. These are coagulated, washed, and dried. The product is Perbunan. It is dark brown in color and bears some resemblance to natural rubber.

Further processing is done on the usual rubber machinery. The Perbunan is milled to break it down and then certain additions are milled in; plasticizers and softeners to improve the flexibility at low temperatures; accelerators to reduce curing time; sulphur, a curing agent; and zinc oxide or carbon black to act as a filler and increase the tensile strength and hardness. This mixture is formed into tubes or sheets, cut to size, and cured in a mold under pressure at a temperature of 275 to 325 F for approximately 20 min.

Buna N and Hycar are also made from Butadiene and acrylonitrile but mixed in different proportions and polymerized by different methods. The processing and curing is similar to Perbunan.

The physical properties of the cured synthetic-rubber stock can be made to vary between wide limits depending upon the condition of the raw stock, the kinds and percentages of ingredients added during compounding, and the temperature and length of cure. Because of these variables, processors of important synthetic-rubber parts have found it expedient to install effective process control. As a double check, most users of critical parts conduct laboratory tests for swelling, shrinkage, low-temperature flexibility, tensile strength, etc., on each lot of parts before releasing them to assembly. This procedure has been well worth the cost.

Before aromatic fuels came into extensive use, Neoprene was commonly used for gasoline seals. It is a polychloroprene. The structural formula for one unit of the Neoprene polymer is



It is handled on the usual rubber machinery, compounded, and cured by processes similar to Buna N.

Several types of Neoprenes have been developed. Type GH has a fast cure rate and good flexibility at low temperatures. Type FR which designates "freeze resistant" has excellent low-temperature properties.

The outstanding disadvantage of the Neoprenes is that the swelling which takes place in aromatic fuels is in some cases so great as to preclude its use. Thin coatings of other synthetic rubbers are sometimes applied to the Neoprene to protect it from aromatic fuel.

Several other synthetic rubbers may have applications in fuel-system equipment; among these are the following:

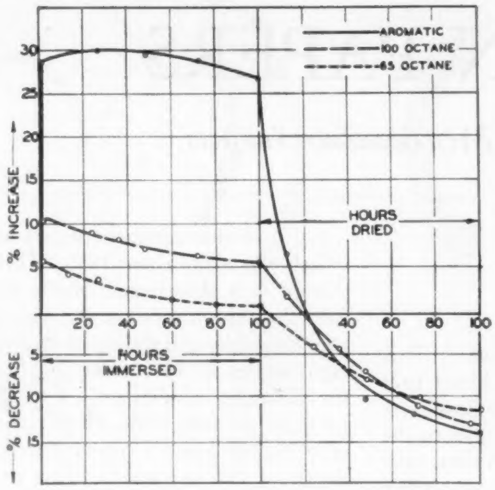


FIG. 9 VOLUME CHANGES OF PERBUNAN PUMP SHAFT SEALS DURING IMMERSION IN GASOLINE AND SUBSEQUENT DRYING IN AIR AT ROOM TEMPERATURE

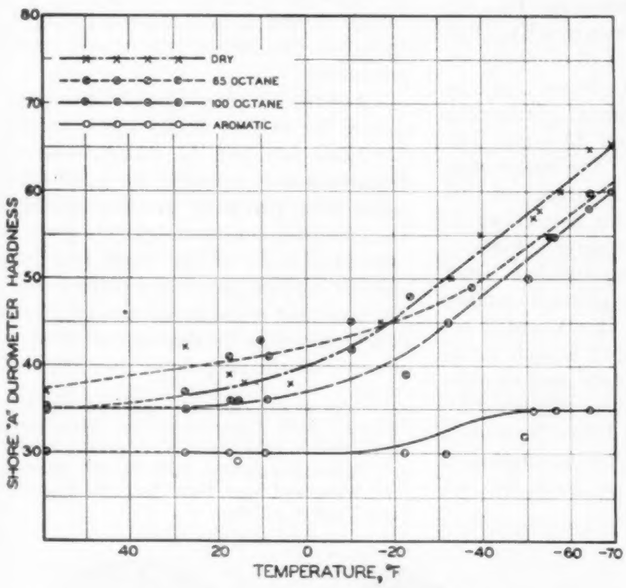


FIG. 10 EFFECT OF DECREASING TEMPERATURE ON DUROMETER READING OF A PERBUNAN STOCK

(Specimens were soaked 24 hr before test.)

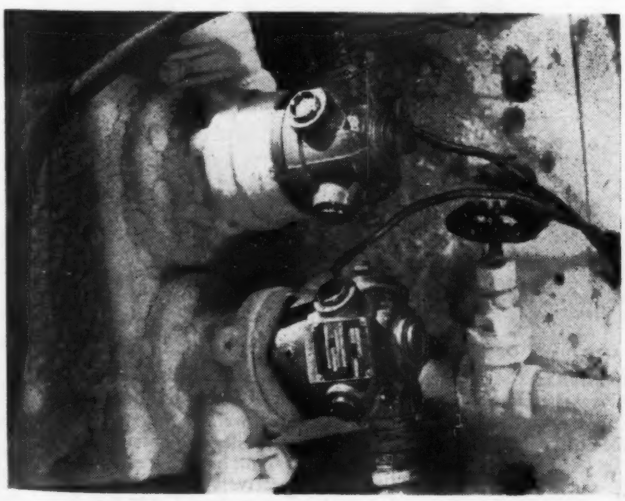


FIG. 11 BOOSTER PUMPS IN COLD CHAMBER

(*a*) Chemigum, a modified diolefin copolymer.

(*b*) Thiokol, produced from dichlor-ethyl-ether and sodium-tetrasulphide, by condensation.

Selection. The selection of a synthetic rubber for a specific part is generally decided after compromises are made between the designer and the vendor of the rubber part. The vendor should be given as complete information as possible at the beginning and kept up to date on test results as the development proceeds. A written specification is helpful. It should briefly describe the application and list the physical properties believed to be necessary and those believed to be desirable; Table 6 is an example.

A sample sheet 6 in. × 6 in. × $\left\{\begin{matrix}0.068 \text{ in.}\\ 0.072 \text{ in.}\end{matrix}\right\}$ thick and one rubber pellet 1 in. diam and $^1/_2$ in. thick of the proposed stock will enable the designer to obtain some preliminary data on the stock. If, in production, the part is to be molded, it is desirable to make a single-cavity mold as early in the development as practicable so the soak tests can be repeated on the actual part.

Fig. 9 shows the plotted data on extended soak-and-dry-out tests of a Perbunan booster pump-seal diaphragm. Note that the maximum swelling occurs in less than 24 hr, but shrinkage upon drying out at room temperature does not reach a maximum for about 100 hr. The design of the part is such as to accommodate the shrinkage without impairing the performance of the seal.

There is need for a standard method for obtaining quantitative data to compare the flexibility of rubber stocks at low temperatures. The S.A.E.–A.S.T.M. bent-loop method permits the evaluation of the bend-brittle temperature. Some laboratories supplement these data with a test to determine how much load a cantilever specimen can support within a certain limit of deflection. This gives useful comparative data. Another method is to measure the Shore durometer of the stock at various temperatures. Fig. 10 shows the increase in durometer of a Perbunan stock with decreasing temperature. It so happens that the physical design of the actual part is thin enough to counterbalance the increasing stiffness of this synthetic rubber at subzero temperatures.

Performance Tests. The last step is to subject the fuel-system accessory to laboratory tests which simulate the most severe conditions likely to be encountered in service. Operation at —65 F is the most difficult of these at present. A fuel system incorporating the particular accessory is set up in the cold-temperature chamber, and a number of accessories run through several different routines with low-octane fuel, as well as with aromatic fuel. Fig. 11 shows two booster pumps in the cold chamber pumping fuel at —65 F.

The pumps are removed at intervals and dried out for several days. If plasticizer has been extracted by the fuel on the previous runs, the rubber will have lost some flexibility. Further tests pumping gasoline at —65 F will indicate whether or not the seals are still functioning properly.

The low-temperature tests are followed by extended endurance runs at room temperature.

SUMMARY

1 Synthetic-rubber parts, and materials containing synthetic rubber, have provided a convenient and satisfactory solution to the problem of sealing fuel-system equipment.

2 A wide variety of properties are available in synthetic rubbers.

3 The best physical form of a synthetic-rubber part to meet the specific requirements is arrived at by making provisions in the design for the limitations of the rubber stocks available.

4 Once the design is set and a specific rubber stock selected, close control of production quantities is necessary to assure consistent performance.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Cutting-Angle Relationships on Metal-Cutting Tools

COMMENT BY O. W. BOSTON[1]

This paper[2] is based upon the premise that "the angle of greatest importance in metal cutting is the true rake angle." The author defines the true rake angle "as the actual slope of the tool face with respect to a plane passing through the axis of rotation and the point of the tool (or a plane parallel to this reference plane) and is measured in a plane perpendicular to both the reference plane and the projection of the cutting edge on that reference plane." This obviously applies to milling cutters.

The writer challenges first the statement that the rake angle is the most important in general metal-cutting action; particularly in single-point tools, tool life is affected much more by a variation of side-cutting-edge angle than by the rake angles, and the side rake angle is of much greater importance than the back rake angle. The author has not shown any values to prove his statement, and these values would indeed be interesting to see, if available.

The author's mathematical analysis of determining the true rake angle is based upon a premise "that the chip usually flows in a direction approximately perpendicular to the cutting edge."[2] He states further in the Supplement, "the definition of true rake indicated in the American Standard ASA B5.13, 1939, (for single-point tools) cannot be upheld because of the implied exact relationship between true rake and chip flow, whereas the true rake angle is actually a property of the cutting tool only." The writer is the author of this definition which reads as follows: "The true rake angle, under actual cutting conditions, is the actual slope of the tool face toward the base from the active cutting edge in the direction of chip flow. It is a combination of the back rake and side rake angles and varies with the setting of the tool and with the feed and depth of cut." This definition is based upon the belief that the chip does not necessarily flow over the face of the tool at right angles to the cutting edge. Further, that the true rake angle will be different as the tool setting angle and feed and depth of cut are changed, in spite of the fact that the tool shape remains constant.

Apparently, none of the members of the Nomenclature Committee, T.C. 17, or of the Sectional Committee B5, or of the sponsoring societies (all of whom approved this definition) knew "of the historically accepted concept of true rake (which dates back about 80 years)" referred to by the author. The writer must personally confess his ignorance of this concept, even though for more than 20 years he has been compiling a bibliography on metal cutting and has listed every article with an abstract coming under his observation. One A.S.M.E. research bulletin, listing 778 such references, was published in 1930, and an additional 1280 references were published by the writer personally in 1935. Now both of these, with about 5000 more references, are being printed in one book by the A.S.M.E.

Fig. 1 of this comment shows a print[3] which was made about 1930. This illustration was shown specifically to indicate that the marks on the face of the tool caused by the sliding chip are not at right angles to the cutting edge but vary for different conditions. Fig. 2, prepared at the same time, shows the direction of chip flow for constant feed as the depth of cut is varied. This evidence assisted the writer in forming an opinion of the definition of true rake, which he still believes to be correct as given in the American Standard for the Nomenclature of Single-Point Tools, referred to.

Figs. 1 and 2 have also been reproduced in the writer's text[4] on metal processing.

When the writer prepared the nomenclature for milling-cutter teeth for the American Standard on milling cutters, definitions were prepared for axial rake, radial rake, true rake, and normal rake. The definition for normal rake is given as "the rake angle of the tooth face in a plane at right angles to the cutting edge. The true rake is the actual working rake as determined by the direction of the flow of chip. If the chip flows over the tool

[3] Given as Fig. 101, in "Engineering Shop Practice," John Wiley & Sons, Inc., New York, N. Y., vol. 1, 1933 (now out of print), p. 121.

[4] "Metal Processing," by O. W. Boston, John Wiley and Sons, New York, N. Y., 1941, Figs. 7 and 8, p. 100.

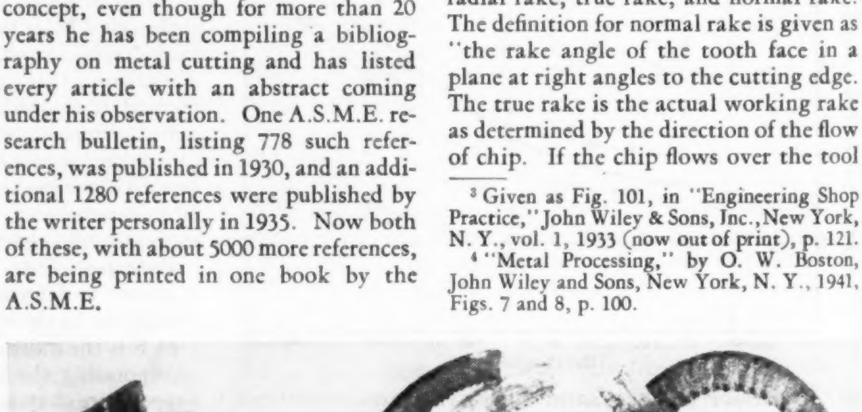


FIG. 1 VIEW OF CHIPS AND FACE OF A TOOL WHEN TURNING SAE 1045 STEEL ANNEALED

(The dashed lines are approximately parallel to the abrasion marks on the tool face caused by the flowing chip. They therefore represent the direction of chip flow over the face of the tool for the several conditions. The tools of high-speed steel were $^3/_8$ in. wide; they had 8 deg back rake, 14 deg side rake, 6 deg end relief, 6 deg side relief, 10 deg end-cutting-edge angle, with a nose radius of $^1/_{32}$ in. The depth of cut was constant at $^1/_8$ in., but the feed was, from left to right, 0.0104, 0.0204, and 0.0416 in. per revolution, respectively. The wear and chips shown were produced 1 min after the tool started to cut at a speed of 85 fpm.)

[1] Professor of Metal Processing, and Chairman, Department of Metal Processing, College of Engineering, University of Michigan, Ann Arbor, Mich. Mem. A.S.M.E.

[2] "Cutting-Angle Relationships on Metal-Cutting Tools," by M. Kronenberg, MECHANICAL ENGINEERING, vol. 65, 1943, pp. 901–904; and Supplement, publication M1308-S, the Cincinnati Milling Machine Co., Cincinnati, Ohio.

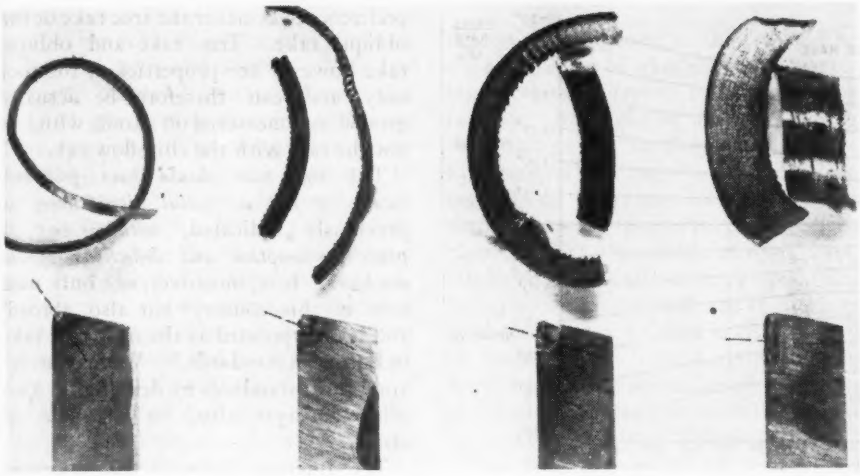


FIG. 2 VIEW OF CHIPS AND FACE OF FOUR TOOLS SIMILAR TO THOSE OF FIG. 1 WHEN TURNING SAE 1045 STEEL ANNEALED AT 80 FPM

(The dashed lines are drawn approximately parallel to the abrasion marks caused by the flowing chip on the face of the tool. These conditions as shown are after 2 min of cutting, using a freshly ground tool in each case. The feed was constant in all four cases at 0.0204 ipr; the depths were, from left to right, 0.0312, 0.0625, 0.125, and 0.250 in., respectively. The direction of flow of chips is indicated and the dashed lines seem to swing counterclockwise as the depth of cut is increased.)

face at right angles to the cutting edge, the true rake equals the normal rake." This suggests that the author might use the term "normal" rake as being the angles developed by him mathematically, while the writer believes that true rake is an angle that occurs for every single cutting condition and may vary considerably from the normal rake. Presumably, for commercial purposes, the error caused by using normal rake as computed for true rake would not cause serious difficulty, as again, it is felt that a slight change in rake angle, whether it be normal or true, is of rather minor consequence.

AUTHOR'S CLOSURE

Professor O. W. Boston's challenge is greatly appreciated because it renders an opportunity to discuss basic concepts of metal-cutting problems not sufficiently clarified and understood.

The definition of the true rake, as used in this paper and in the Supplement,[2] applies to all types of metal-cutting tools and not only to milling cutters as Professor Boston erroneously assumes.

This will become clear from Fig. 3 of this closure, which is an artist's view of a milling cut showing a tooth of a face mill in engagement with the work. The axial rake and the radial rake are shown negative in this picture.

It will not be difficult to visualize from Fig. 3, that a planer cut results if the cutter axis is moved to infinity. The definitions, however, will not be affected thereby. The same holds for boring, represented by Fig. 3, if the rotation is assigned to the work rather than to the tool. Drilling is likewise covered by the illustration. Hence the definitions apply to all these cases of metal-cutting and also to turning operations as was shown in Fig. 6 of the Supplement, where the reference plane likewise passes through the axis of rotation and the point S of the tool. In turning, the axial rake corresponds to the back rake, the radial rake to the side rake, and the corner angle to the effective side-cutting-edge angle.

Professor Boston's statement, "tool life is affected much more by a variation of the side-cutting-edge angle than by the rake angles, and the side rake angle is of much greater importance than the back rake angle," supports our opinion regarding the true rake rather than contradicting it as he implies. This can be seen from Equation [5] of the paper for the true rake

$$\tan t = \tan r \cdot \cos c + \tan a \cdot \sin c$$

If in this formula the side-cutting-edge angle c is small (say 15 deg as in Professor Boston's tests), the term "$\tan a \cdot \sin c$" will be small and, consequently, the true

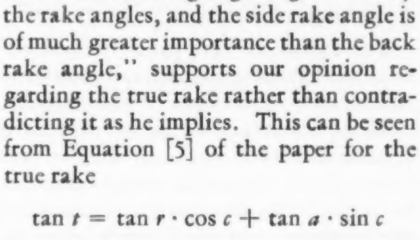


FIG. 3 TRUE RAKE AND ITS COMPONENT ANGLES ON METAL-CUTTING TOOLS

rake t will be affected appreciably more by a change in the side rake r, than by a change in the back rake a. This result agrees with Professor Boston's statement, who, however, does not recognize that the reason for the variation in tool life with side rake is due to variation in the true rake, which in this case is almost equal to the side rake!

If, on the other hand, the side-cutting-edge angle c is not small but increases from 15 to 45 deg, the true rake is likewise changed, and hence the tool life is affected. Professor Boston interprets this change as an effect of the angle c, instead of interpreting it, as we do, as the result of a change in the true rake caused by the change in angle c.

If the concept of true rake is used in evaluating tool-life tests, or cutting-force tests, it will be appreciably easier to correlate results which in Professor Boston's tests do not seem to be related to each other. It will then not be necessary to describe a multitude of variations difficult to comprehend.

Professor Boston's further assumption, "the author's analysis . . . is based upon the premise that the chip usually flows in a direction approximately perpendicular to the cutting," is likewise erroneous. It can be seen from Equation [5] that the true rake is independent of the chip flow, a fact which has also been explicitly stated in the Supplement.

The first one to introduce the concept of "true rake" as an angle of the tool was to our knowledge a Swedish professor by the name of G. Sellergren, who published a paper,[5] in 1896, the title of which can be freely translated as: "Measurement of Metal Cutting Forces." Sellergren comments on previous publications, one by the Russian author, J. Thime,[6] and the other one by the French engineer Joessel, employed in 1865 by the Navy Yard at Indret. Sellergren points out that the cutting angle defined by Thime is not the true cutting angle because the inclination of the cutting edge is not taken into account. Sellergren suggests measuring the "true cutting angle" (the complement of our true rake) in a plane located in the direction of motion of the tool.

Sellergren's concept of true rake as an angle of the tool has obviously the great advantage of measuring true rake in the plane of the component of the cutting force that determines the power consumption and deflections of the machine! This is of primary importance in the design of machine tools, particularly today, in view of new developments asso-

[5] "Das Messen des Widerstandes der Metalle bei Anwendung von Schneidestählen," by G. Sellergren, *Zeitschrift des Oesterr. Ingenieur und Architekten Vereines*, vol. 48, 1896, pp. 473–478.

[6] "Mémoire sur le rabotage des métaux," by J. Thime, St. Petersburg, Russia, 1877.

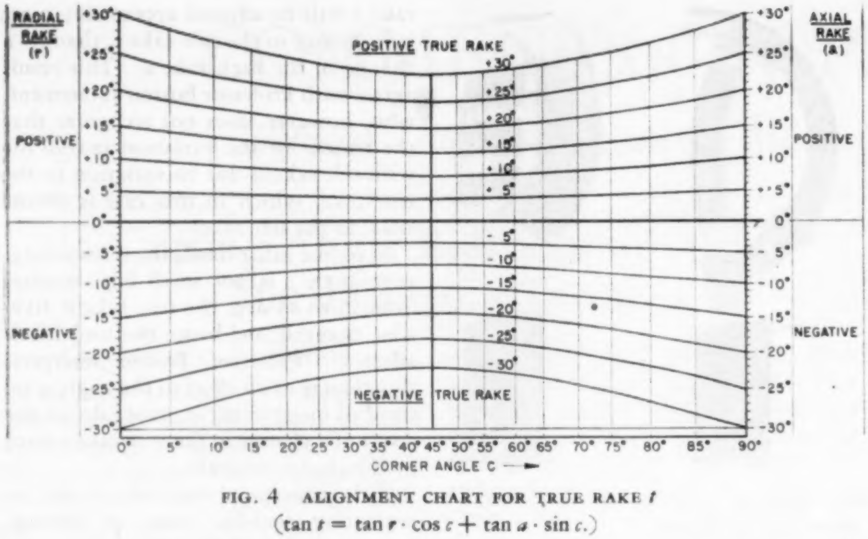


FIG. 4 ALIGNMENT CHART FOR TRUE RAKE t

($\tan t = \tan r \cdot \cos c + \tan a \cdot \sin c$.)

ciated with high-speed milling with negative rakes.

Another advantage of such a definition of true rake is its independence of the direction of chip flow, hence the true rake can readily be ground on the tool and determined, either by using Equation [5], or by Figs. 1 and 2, of the paper, which have now been combined into the single diagram shown here as Fig. 4.

In Professor Boston's definition, the true rake is not a property of the tool itself, but depends upon chip flow, i.e., on friction, on the material of tool and work, on the feed and depth of cut, on the cutting fluid, etc. We would suggest calling such an angle the "chip-flow rake" which would be defined as follows:

The chip-flow rake is the actual slope of the tool face with respect to a radial plane (reference plane) of the rotating body, passing through the sharp point of the tool, and is measured in a plane parallel to the direction of chip flow, and perpendicular to the generated surface.

This corresponds to the angle defined by Professor Boston as the true rake angle. If such a definition is accepted, we would have to incorporate into the American Standards definition three concepts, all referring to the combination of the three basic tool angles. All concepts are defined as angles between the reference plane and the tool face, but measured in different planes:

1 The "true rake" measured in a plane in the direction of travel.

2 The "oblique rake," measured in a plane perpendicular to the cutting edge.

3 The "chip-flow rake" measured in a plane parallel to the direction of chip flow.

Adoption of these three rake definitions would eliminate the Babylonian confusion existing at present, leaving it to the individual investigator as to which rake he wants to refer his tests.

It would certainly not be justifiable to confine the measurement of the rake angle to the direction of chip flow as Professor Boston suggests. Merchant[7] has shown that the force system acting on the tool depends, among other variables, upon a rake angle which is a characteristic of the cutting tool used, irrespective of direction of chip flow. He also indicates that the chip-flow rake has no preference over either the true rake or the oblique rake. True rake and oblique rake however are properties of the tool only and can therefore be actually ground and measured on a tool, which is not the case with the chip-flow rake.

The *true rake should have preference because it has a special significance*, as previously indicated, *with respect to power consumption and deflections of the machines*. It is, moreover, not only used now in this country[8] but also abroad[9] and is incorporated as the only true rake in European standards.[10] We may go beyond these standards by defining the two other concepts also, for the sake of clarity.

The difference between true rake and oblique rake is usually very small except in cases of milling cutters with large helix angles, and similar cases. The oblique rake is convenient in mathematical equations; it can always easily be converted into the true rake by means of Equation [11] of the Supplement, a formula dating back to Sellergren.

M. KRONENBERG.[11]

[7] "Basic Mechanics of the Metal-Cutting Process," by M. E. Merchant, *Journal of Applied Mechanics*, Trans. A.S.M.E, vol. 66, 1944, pp. A-168 to A-175.

[8] "Metal Cutting Tools," by A. L. De Leeuw, McGraw-Hill Book Company, Inc., New York, N. Y., 1922, p. 25.

[9] "Werkzeugmaschinen," by G. Schlesinger, Julius Springer, Berlin, 1936.

[10] Switzerland, Germany.

[11] Research Department, The Cincinnati Milling Machine Company, Cincinnati, Ohio.

Material Handling

COMMENT BY EDWARD SOUTHWORTH[12]

The author of this paper[13] points out that the handling of materials adds only to cost and not to value; that it has more possibilities for cost reduction than most production functions; and that it promotes greatly increased safety. Further he states: "We obviously disregard the one common operation which often requires more human effort and absorbs the greatest portion of labor cost while the processing of the product is taking place." And, "Just as we improved machines and tools and instruments of production so that we no longer have to produce by handicraft methods, so we can apply engineering ingenuity to material-handling operations... until... the more laborious and costly operations will be mechanized or entirely eliminated."

The significance of these last two statements, the writer would like to emphasize. A scale for measuring materials-handling efficiency is much needed to help us locate inefficiencies and to prove to management that the better methods we propose really are better.

Such a scale is a tool we need badly because no accounting system has yet been devised which records handling costs as such and permits adequate analysis of them. As is well known, accounting systems traditionally classify handling costs under overhead, and there they remain as "hidden costs," seldom subjected to management's scrutiny.

A few years ago, an able executive undertook to modernize an old-fashioned glass container plant. Starting with production processes, he made great strides in lowering costs, but the total result did not satisfy him. Then he began to examine the possibilities for improving handling.

When he referred the situation to the writer's company, he described the job of storing glass containers in a large warehouse, including transporting them from the packing room and later delivery to and loading in outgoing railway cars and highway trucks. Then he asked what the cost would be with our method. We estimated that two fork trucks with their operators and two helpers could do the job. At that point he said, "Sorry, you cannot help us, we're doing the job with four men now." That seemed unusual to us, so we asked permission to inspect the operation and found eight men at work in the warehouse and one in the packing room and were told that often

[12] Sales Promotion Manager, Towmotor Corporation, Cleveland, Ohio.

[13] "Material Handling—A Field for Industrial Progress," by R. W. Mallick, MECHANICAL ENGINEERING, vol. 66, 1944, pp. 447–450.

one or two other men were brought in to help load cars and trucks. The discrepancy puzzled him as much as it did us, and questioning revealed that four men were regularly charged to warehousing, four to shipping, and one to packing room, plus the additional one or two for rush work. Actually all of them worked as a gang, but the records showed only four charged to the handling job.

Since then, the warehouse capacity has been more than doubled and five men have been transferred to direct production work at higher rates. And yet, if the management had continued to depend upon records, the old system would have seemed satisfactory.

Not long ago we visited an automotive-parts plant which has used a fork truck for a long time. Results had been very satisfactory. We found, for instance, that one man with the fork truck could load a box car of small forgings in 3 hr. By the old method, it took 3 men 16 hr to do the same amount of work.

Realizing that this was only a small part of the truck's work and that other savings were nearly as dramatic, we asked the comptroller for the picture on savings. He replied, "The savings are so obvious we do not even record them."

Now, that made us feel mighty happy about the accomplishments of our equipment and it made us feel pretty secure, too. But fundamentally we cannot agree with that point of view, for that company is going to have to depend upon prodding from the outside or a temporary breakdown of the present system, before it will investigate still newer and better methods. It seems to the writer to be a good example of an attitude that could be overcome by the use of an adequate scale of measurement for handling costs.

This situation is not the result of lazy thinking. It is the result of the difficulties inherent in costing handling operations. Production cost methods are predicated on one operation, on one piece, by one machine working in a fixed location. Contrast that with handling where a crane or conveyer may handle dozens of different pieces in succession over the same route or a part of the same area. Then, think of the additional complexity of handling by trackless equipment, which can be used anywhere in the plant over widely varying distances and which may move some material for all departments the same day or in a few hours.

There are two general methods of approach. The first is by a system of spot checks, in the form of time studies of typical job cycles, or similar studies of job units, such as loading or unloading a car or truck, or conveying 1 hour's or 1 day's production requirements of parts between successive processes. It is quick and relatively easy but lacks the advantages of continuous and comprehensive reports. The second method would be the application of standard cost-accounting methods, adapted to the handling function. It might be done by costing each unit of the handling operation, or by recording the cost of handling a given number of each unit of the product throughout its progress through the plant. Another approach, in some cases, might be to cost all handling operations for an accounting period and apply them to the number of finished units produced in that period. Such a system would apply where there are relatively few items in the line and where the handling operations are similar for all items.

The recommendation offered by the writer is that a study of cost recording and analysis methods be made, bearing in mind that the rules should be general enough for wide application and allowing for the possibility of minor changes to fit individual situations.

It would seem to be a very worth-while project, because it should have the following important benefits to those in charge of practically all phases of production and distribution:

1 Enable management to become aware of obsolete methods.

2 Afford a ready means of comparing methods and equipment.

3 Give a constant check on costs which might otherwise be overlooked.

Author's Closure

Mr. Southworth's comments portray well conditions that are frequently encountered in industrial plants. Very few companies, if any, know the true costs of their material handling, as it is the author's experience that most companies make no attempt to segregate such costs. Material handling is usually absorbed in indirect operating expenses or made a part of productive operations; hence, it is impossible to develop a true cost. It is the lack of this kind of information which is to a great extent hampering the progress which could and should be made in improving this parasitic operation. American industry will reach a new level of efficiency undreamed of today when real progress is made in the field of material handling.

R. W. Mallick.[14]

[14] Section Engineer, Headquarters Manufacturing Engineering Department, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. Mem. A.S.M.E.

Methods Improvement

Comment by J. M. Juran[15]

The most significant feature in connection with this paper[16] is that we have commenced to think in terms of attitudes at all. All about us are instances which leave inescapable conclusions that state of mind is a far greater force than state of things. Safety mindedness is of greater importance than safety devices in securing a safe plant. Quality mindedness is of greater importance than the measuring devices in securing a high standard of quality. Even in the prosecution of the war, the will to fight has been more important than the physical weapons. In all these matters, given the correct attitude, the physical plant can be a valuable adjunct in achieving the objective. However, in the absence of correct attitude, no amount of physical plant will of itself achieve the objective. The achievement of methods improvement is no exception to all this.

It is significant that a union labor executive is invited to address a meeting of this Society, and that in the presence of a union labor executive, a manager dares to share the platform. A few years ago both of these events would have been unthinkable.

It is further significant that there is general agreement that, in achievement of methods improvement, the employee should be on the team. The author and his associates said this for many years before it began to be practiced. That it is taking hold is only another manifestation of the timeless determination by all people that they shall have a voice in matters which affect their welfare.

Finally, it is significant that recent papers and discussions on improving methods have produced no important disagreements. The area of agreement is far greater than the area of controversy.

[15] Assistant to the Administrator, Foreign Economic Administration, Washington, D. C. Chairman, Management Division, A.S.M.E.

[16] "Attitudes Toward Methods Improvement," by C. S. Golden, Mechanical Engineering, vol. 66, 1944, pp. 465-466 and 429.

Wanted—An Interprofessional Information Club

To the Editor:

The Club I propose should contain members of engineers, physicians, dentists, chemists, (etc.)".

The Club would set out to exchange interesting information by any specialist in his field for the benefit of laymen in that particular field. Thus the start. But valuable practical application will inevitably crop up more often than we anticipate. For example, on a given evening a dentist lectures to laymen (that is, laymen in dentistry) on the mechanical and chemical problems of dentistry—mechanical engineers and chemists "rush to the rescue."

Incidentally, the dentist may conclude with *recent* developments in dental hygiene; the stomach specialist may conclude with *recent* developments in dietetics; the nerve specialist may conclude with mental hygiene, etc.

B. Spector.[17]

[17] New York, N. Y. Mem. A.S.M.E.

BOOKS RECEIVED IN LIBRARY

Air Conditioning and Refrigeration. By B. H. Jennings and S. R. Lewis. Second edition. International Textbook Co., Scranton, Pa., 1944. Fabrikoid, 6 × 9 in., 517 pp., illus., diagrams, charts, tables, $4.50. This book, published first in 1939 with the title, "Air Conditioning, Principles and Practice," aimed to present the fundamentals of air conditioning so as to provide engineering students and practicing engineers with a sufficient basis for work in this field. This new edition has been thoroughly revised and modernized, and the information on refrigeration greatly extended, so that the book can also serve as a text on that subject.

Aircraft Mechanics Handbook, edited by P. Van Winkle. Manual Arts Press, Peoria, Ill., 1944. Cloth, 5 × 7$^1/_2$ in., paged in sections, diagrams, charts, tables, $2.75. The object of this book is to provide a guide and reference work for apprentices, students, repair mechanics, factory workers, and engineers. It contains specifications on aircraft materials, technical data, and information on replacement and identification of parts and repair of aircraft structural surfaces and accessories. It is based on the latest Army-Navy and Commercial specifications.

American Society for Testing Materials, Proceedings of the Forty-Sixth Annual Meeting held at Pittsburgh, Pa., June 28–July 1, 1943. Vol. 43, Committee Reports, Technical Papers. Published by the American Society for Testing Materials, Philadelphia, 1944. Paper and cloth, 6 × 9$^1/_4$ in., 1349 p., illus., diagrams, charts, tables; paper, $8.50, cloth, $9. This volume contains the committee reports presented at the Annual Meeting and the technical papers, symposiums, and lectures delivered.

Automatic Control Engineering. By E. S. Smith. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Cloth, 5$^1/_4$ × 8$^1/_2$ in., 367 pp., diagrams, charts, tables, $4. This book brings together for the first time, in the English language, a general discussion of processes of control, control mechanisms, and servomechanisms. The purpose has been to provide tools designed to aid the solution of problems in automatic regulation wherever they occur. The subject is first approached qualitatively and then analyzed quantitatively. Appendixes provide a review of the basic physics and of the mathematics of physical transients.

Centrifugal Pumps and Blowers. By A. H. Church. John Wiley & Sons, New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, 5$^1/_2$ × 8$^1/_2$ in., 308 pp., illus., diagrams, charts, tables, $4.50. This discussion of centrifugal pumps and blowers is a welcome addition to the scanty literature on modern practice. The work covers the basic principles of design in sufficient detail for practical purposes and discusses accepted practice in the construction of details and in materials. The selection of pumps and blowers and their installation, operation, and testing are also treated.

Down to Earth: Mapping for Everybody. By D. Greenhood. Holiday House, New York, N. Y., 1944. Cloth, 8$^1/_2$ × 11$^1/_4$ in., 262 pp., diagrams, charts, maps, tables, $4. This book, written for the amateur, provides a general survey of maps and map making. The theories and techniques of mapping are developed in simple language, yet clearly and explicitly. Directions are given for making maps and for collecting them. The book is profusely illustrated and will interest map makers and users alike.

Engineering Inspection Practice. By A. T. King, foreword and preface by H. H. Sheldon. Chemical Publishing Co., Brooklyn, N. Y., 1944. Cloth, 5$^1/_2$ × 9 in., 242 pp., illus., diagrams, charts, tables, $3. This book is intended to meet the need for a text covering the inspection methods necessary for the efficient functioning of today's high-speed production. Beginning with the reading of working drawings, it continues with descriptions of the types of measuring instruments and their methods of use. Engineering materials, engineering hardening processes, hardness testing, and other mechanical testing methods are discussed. There is a separate chapter which is devoted to aeronautical inspection.

Engineering Materials Annual 1944, editor, H. H. Jackson. Paul Elek (Publishers) London, W.C.2, England. Cloth, 5 × 8$^1/_4$ in., 108 pp., 8s 6d. This little manual gives a concise review of important developments in engineering materials during the year 1943. It includes articles on ferrous and nonferrous metals, plastics of all kinds, ceramic materials, fuels, lubricants, plywood, and adhesives. Each review is accompanied by a bibliography.

Engineering Production Annual 1944, editor, H. H. Jackson. Paul Elek (Publishers) London, W.C.2., England. Cloth, 5 × 8$^1/_4$in., 102 pp., 8s 6d. This little volume reviews developments during 1943 in machine-shop methods, machine tools, welding, powder metallurgy, hardening, etc. Each review is accompanied by a list of references to the articles from which the review was prepared.

Experimental Stress Analysis, Proceedings of the Society for Experimental Stress Analysis, vol. 1, no. 2, held at Hotel Pennsylvania, New York, Dec. 2–4, 1943. Addison-Wesley Press, Cambridge, Mass., 1944. Cloth 8$^1/_2$ × 11$^1/_4$ in., 132 pp., illus., diagrams, charts, tables, $4. The Society, which is a reorganization of the former Eastern Photoelasticity Conference, presents its second publication. Fifteen papers are included, dealing with methods of stress measurement and stress analysis in heavy machinery, aircraft, and other structures. The volume also includes synopses of the papers contributed by the Applied Mechanics Division of The American Society of Mechanical Engineers and presented at the joint meeting in December, 1943.

Extrusion of Metals. By C. E. Pearson, with a foreword by R. Genders. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, 5$^1/_2$ × 8$^3/_4$ in., 205 pp., illus., diagrams, charts, tables, $3.75. We have here a concise account of extrusion practice relating to different classes of work and materials, based on the widely scattered information available in the literature and on the author's own studies. Chapters on flow phenomena in the process and on the influence on the extrusion of metals of such factors as temperature and the speed and extent of deformation are included. Impact extrusion is also discussed.

Gears. By H. E. Merritt. Sir Isaac Pitman & Sons, London, England; Pitman Publishing Corporation, New York, N. Y., 1943. Cloth, 5$^3/_4$ × 9 in., 420 pp., illus., diagrams, charts, tables, $8.50. The subject of gears and gear action is treated from a general viewpoint with the object of emphasizing similarities. The early chapters cover gear classification, fundamental characteristics, and the principles and analysis of tooth contact. Gear-tooth generation is dealt with at length, followed by a discussion of gear materials and the mechanical properties of gear teeth. The chapter on tooth proportions is extensive, and chapters are also devoted to lubrication, tolerances, gear trains, and tooth reactions.

Jig and Fixture Practice. By H. C. Town, Paul Elek, Ltd., London, England, 1944. Cloth, 5 × 8 in., 120 pp., illus., diagrams, charts, tables, 10s 6d. A concise compendium of information on the design and construction of conventional jigs and on pneumatic and hydraulic operation, plastic jigs, welded jigs, and router jigs.

Laying Out for Boiler Makers and Plate Fabricators, revised by G. M. Davies. Fifth edition. Simmons-Boardman Publishing Corporation, New York, N. Y., 1944. Cloth, 8$^1/_2$ × 11$^1/_4$ in., 522 pp., illus., diagrams, charts, tables, $7. This book is designed as a practical text for the solution of problems in laying out plate for boilers and similar vessels. Only simple mathematics is used. The new edition has been thoroughly modernized. New material has been added on laying out boiler patches and on laying out for welded construction.

Manual of Firemanship, Part 2, Appliances. Great Britain. Home Office (Fire Service Department). His Majesty's Stationery Office, London, 1944. Paper, 5$^1/_2$ × 8$^1/_2$ in., 186 pp., illus., diagrams, charts, tables, 2s 6d. (Obtainable from British Information Services, New York, N. Y., $0.75.) The Manual of Firemanship, issued by the Fire Service Department of the British Home Office, is a comprehensive survey of fire fighting and fire prevention. The present section discusses appliances, including pumps and their operation, ladders of all types for fire fighting and rescue work, and such special appliances as hose carriers, foam equipment, smoke exhausters, mobile kitchens, etc.

Mathematics for Exterior Ballistics. By G. A. Bliss. John Wiley & Sons, Inc., New York, N. Y., and London, England, 1944. Cloth, 5 × 8 in., 128 pp., diagrams, charts, tables, $2. The major part of this book deals with the elementary calculus and differential equations used in the theory and computation of the trajectories of shells and their differential corrections listed in range tables for artillery fire control. There is also a brief general discussion of bombing from airplanes. Tables for computation are included.

Metallography of Some Aluminium Al-

Library Services

Engineering Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

loys. (Association Series No. R.R.A. 635.) By M. D. Smith. British Non-Ferrous Metals Research Association, London, N.W.1, England, November, 1943. Paper, $6^1/_4 \times 9^3/_4$ in., 12 pp., illus., charts, tables, 2s. This brochure describes work on the constitution and metallography of aluminium alloys in common use. Cooling curves were taken and the structure of the alloys examined in the cast condition and after quenching from various temperatures. There are twenty-eight photomicrographs.

Microfilming. By R. De Sola. Duell, Sloan & Pearce (Essential Books), New York, N. Y., 1944. Cloth, $4 \times 6^1/_4$ in., 258 pp., illus., diagrams, charts, tables, $1.50. This small book gives an excellent account of this process of reproduction, its uses and advantages. Much practical information is supplied on cameras, methods of processing and printing, and on enlarging and reading microfilm.

Modern Operational Mathematics in Engineering. By R. V. Churchill. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1944. Cloth, $5^1/_4 \times 8^1/_2$ in., 306 pp., diagrams, tables, $3.50. In this volume, a companion to a previous one on Fourier series, the two principal topics treated are partial differential equations of engineering and Laplace transformations. The operational properties of the Laplace transformation are derived and carefully illustrated and are used to solve problems in vibration and resonance in mechanical systems, with some attention to electrical analogues of these problems. Problems in the conduction of heat, potential, etc., are treated by this or related methods.

Ordinary Differential Equations. By E. L. Ince. Dover Publications, New York, N. Y., 1944. Fabrikoid, $5^1/_2 \times 9^1/_4$ in., 558 pp., diagrams, tables, $3.75. This book originally appeared in 1927 and was at once accepted as a standard work on its subject. It has for some time been out of print, and this edition, costing about one fourth the original price, will be welcomed by mathematicians, engineers, and others.

Photomicrography in Theory and Practice. By C. P. Shillaber. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Cloth, $5^1/_2 \times 8^1/_2$ in., 773 pp., illus., diagrams, charts, tables, $10. This is a comprehensive reference book for those interested in the technique of photomicrography. Actual procedures are discussed, with full explanations of how the best results may be had with various subject matters. The work covers the basic principles applicable to all fields of photomicrography.

Physics of the Twentieth Century. By P. Jordan, translated by E. Oshry. Philosophical Library, New York, N. Y., 1944. Cloth, $5^1/_2 \times 8^1/_2$ in., 185 pp., $4. This book, which appeared in Germany a few years before the present war, aims to give in broad outline a complete picture of modern physics. Attention is concentrated on the underlying ideas that have guided the efforts of physicists from the time of Galileo to the present day.

Plastic Working of Metals and Non-metallic Materials in Presses. By E. V. Crane. Third edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1944. Fabrikoid, $5^1/_2 \times 8^1/_2$ in., 540 pp., illus., diagrams, charts, tables, $5. In this edition the author has expanded his work on sheet-metal working and forging to include powdered metals, synthetic plastic powders, and other materials now worked plastically. The methods used in working these materials are studied and described in considerable detail, and an effort is made to classify the metalworking operations into groups and to establish a working theory for predicting results with various materials.

Principles of Powder Metallurgy. By F. Skaupy. Philosophical Library, New York, N. Y., 1944. Cloth, $6 \times 9^1/_4$ in., 80 pp., illus., diagrams, charts, tables, $3. This is a translation of a German book that was published in 1930. It describes briefly the production and properties of metal powders and the methods of production of powdered metal parts, as developed at that time.

Railroads and Public Welfare, their Problems and Policies. By E. R. Johnson. Simmons-Boardman Publishing Corporation, New York, N. Y., 1944. Cloth, $6 \times 9^1/_2$ in., 336 pp., tables, $3. In this volume an expert student of transportation surveys the railroad situation. He traces the development of our railroads, analyzes their wartime problems, and discusses their future. Important questions, such as government versus private operation and the relations of railroad transportation to waterway and highway transportation, are discussed.

Results of Publicly Owned Electric Systems, published by Burns & McDonnell Engineering Co., Consulting Engineers, Kansas City, Missouri, 1944. Paper, $6^1/_4 \times 9$ in., 447 pp., illus., charts, tables, maps, $10. This handbook gives the records, for the year 1943–1944, of publicly owned electric utilities in 767 American cities. Operating data and rates are given. Other features are a comparison of rates of publicly owned and private systems, accounts of the results of public power developments in the Northwest and in the Tennessee valley and of the work of the Rural Electrification Administration.

Symposium on the Applications of Synthetic Rubbers, Cincinnati Spring Meeting, March 2, 1944, American Society for Testing Materials. Published by the Society, Philadelphia, Pa. Cloth and paper, 6×9 in., 134 pp., illus., diagrams, charts, tables; paper, $1.50, cloth, $1.75; to A.S.T.M. members, paper, $1, cloth, $1.25. This pamphlet contains 13 papers presented at the Cincinnati meeting of the Society in March, 1944. The purpose was an authoritative presentation of present knowledge of synthetic rubbers which will aid users in the selection of the best material for various purposes. Among the subjects are: the origin and development of synthetic rubbers; their physical testing and properties; processing characteristics; use in making extruded products; tires and inner tubes; belting and hose; cellular products; hard rubber products; uses in wire and cable; footwear; adhesives.

Thermodynamic Charts, Steam, Water. Ammonia, Freon-12, and Mixtures of Air and Water Vapor; also Special Tables for Turbine Calculations. By F. O. Ellenwood and C. O. Mackey. Second edition. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1944. Leather, $8^1/_4 \times 11^1/_4$ in., 46 pp., charts, tables, $2.75. In the new edition these charts have been corrected wherever necessary and certain ones have been redrawn to make them more usable. A new chart has been added giving the properties of low-quality steam.

Treatise on the Analytical Dynamics of Particles and Rigid Bodies, with an introduction to the Problem of Three Bodies. By E. T. Whittaker. Fourth edition. Dover Publications, New York, N. Y., 1944. Fabricoid, $6 \times 9^1/_2$ in., 456 pp., diagrams, tables, $3.50. This work has long been considered one of the best on its subject and has enjoyed wide use as a textbook and for reference use for mathematicians and physicists. The present publication reproduces the fourth edition, which appeared in 1937, at a reduced price.

Wage Incentives. By J. K. Louden. John Wiley & Sons, Inc., New York, N. Y., Chapman and Hall, London, England, 1944. Cloth, $5 \times 8^1/_2$ in., 174 pp., charts, tables, $2.50. Written for the men of management and of labor, rather than for engineers, this book tells concisely what wage incentives are, what their history has been, and what they can do. The fundamental types of plans are compared. Policies and relations to other functions of management are discussed.

Wood Chemistry. (American Chemical Society Monograph Series No. 97.) Edited by L. E. Wise and others. Reinhold Publishing Corporation, New York, N. Y., 1944. Cloth, $6 \times 9^1/_8$ in., 900 pp., illus., diagrams, charts, tables, $11.50. This comprehensive work contains the contributions of 14 authorities in the field. The material is presented in six parts: Growth, anatomy, and physical properties of wood; components and chemistry of the cell wall; extraneous components of wood; surface properties of cellulosic materials; chemical analysis of wood; wood as an industrial raw material. Extensive reference lists are provided.

Courtesy of Buick

THE NEW M-18 HELLCAT TANK DESTROYER

(Fully armored and mounting a high-velocity 76-mm cannon in a 360-deg power-traversed turret, it is capable of speeds up to 55 mph.)

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Chief of Ordnance Presents Distinguished Service Award to A.S.M.E. at Meeting in Washington

AT a meeting at the Statler Hotel, Washington, D. C., September 6, 1944, Major General L. H. Campbell, Jr., Chief of Ordnance, on behalf of the Ordnance Department, presented to The American Society of Mechanical Engineers the Ordnance Distinguished Service Award (see frontispiece) "in recognition of scientific and engineering achievement."

President Gates Accepts Certificate of Award

R. M. Gates, president A.S.M.E., in accepting the Award said:

"On behalf of The American Society of Mechanical Engineers, I assure you of our high appreciation of this award for our service to Army Ordnance. Our Society, like the engineering profession generally, is gratified that engineers have had extraordinary opportunities, on both the fighting fronts and the production fronts, to contribute to the victory now in sight. We will always cherish this token of the war service of American engineers."

Mr. Gates then called upon Col. James L. Walsh, chairman, A.S.M.E. War Production Committee, who expressed to the representatives of the Ordnance Department the hope and aim of the Society to be of greater service to them in the future.

General Barnes Commends Society for Co-Operation

The meeting, which was attended by representatives of the Ordnance Department and the Society, also provided an opportunity for Mr. Gates to present to Major General G. M. Barnes, Chief, Technical Division, Office of Chief of Ordnance, who delivered the dinner address at the 1944 A.S.M.E. Spring Meeting, Birmingham, Ala., Apr. 3-5 (Mechanical Engineering, June, 1944, pp. 359-362), and who was recently elected a member of the Society, a certificate of A.S.M.E. membership. In his response, General Barnes commended the Society for its policy in encouraging greater co-operation between the Ordnance Department and the A.S.M.E.

Hunsaker, Wesson, and Batt Praise Society's Efforts

Dr. Jerome C. Hunsaker, honorary member A.S.M.E., Major General Charles M. Wesson, honorary member A.S.M.E. and former Chief of Ordnance, and W. L. Batt, past-president A.S.M.E., spoke briefly in commendation of the Society's co-operation with the Ordnance Department.

At the Meeting

Present at the meeting were the following: Major General G. M. Barnes; W. L. Batt; Major General L. H. Campbell, Jr.; W. H. Carrier, honorary member A.S.M.E.; A. G. Christie, past-president A.S.M.E.; C. E. Davies, secretary A.S.M.E.; R. M. Gates, president A.S.M.E.; Jerome C. Hunsaker; Brigadier General H. R. Kutz, Chief, Military Training Service, Office of Chief of Ordnance; M. A. Mason, chairman, A.S.M.E. Washington, D. C., Section; Warren H. McBryde, past-president A.S.M.E.; C. E. Miller, past-chairman, A.S.M.E. Washington, D. C., Section; Col. J. C. Raaen, executive officer, Office of Chief of Ordnance; H. G. Thielscher, nominee for office of manager, A.S.M.E.; Major General W. H. Tschappat, honorary member A.S.M.E.; Col. James L. Walsh; Major General C. M. Wesson, honorary member A.S.M.E.; Ernest Hartford, executive assistant secretary, A.S.M.E.

Registration Fee for Non-Members at the 1944 Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1944 Annual Meeting. For nonmembers wishing to attend just one session (except evening sessions or meal meetings) the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests (male) may avoid this fee by writing to the Secretary of the Society before November 17 asking for a guest-attendance card for the Annual Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member.*

Report to the A.S.M.E. Council of Special Committee on Society Organization Structure

YOUR special Committee on Society Organization Structure, appointed by Harold V. Coes in November, 1943, then president, has discussed the needs of the Society with him, with President Gates and Secretary Davies, and with many members whose experience in Society affairs has made their counsel valuable.

The recommendations of the Committee have been considered under four general headings and will be treated in this order:

(1) Geographic divisions and representation
(2) Committee responsibility
(3) Efficiency of organization
(4) Responsibilities of the Secretary of the Society.

(1) Geographic Divisions and Representation

Your Committee believes that the Society's interests would be better served through geographic subdivisions each headed by a vice-president nominated by, and responsible for, that district. This system has been in operation and has worked well in the A.I.E.E. for many years and your Committee believes it has several advantages over the less directly representative scheme of the A.S.M.E.

(*a*) It tends to make each district more self-reliant and therefore less dependent on headquarters.

(*b*) It gives each district a representative of its own choosing on the Council who brings to the Council the views, needs, and problems

of his district and takes back to it the combined judgment of the members of the Council.

(*c*) It sets up a direct responsibility of a representative to his district; and hence your Committee believes the vice-presidency of a district will attract, and a district will select, the best talent the district membership affords.

The geographic arrangement of districts is as follows:

Group I—New England states.
Group II—New York City and environs.
Group III—New York State, part of Pennsylvania, New Jersey, Delaware, Washington, D. C., and part of Maryland.
Group IV—Virginia, Kentucky, Tennessee, North and South Carolina, Georgia, Alabama, Mississippi, Florida.
Group V—Ohio, West Virginia, Western Pennsylvania, northeastern part of Virginia, Canada (Ontario).
Group VI—North and South Dakota, Nebraska, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Indiana, Michigan, northern part of Kentucky.
Group VII—Washington, Oregon, California, Idaho, Utah, Montana, Wyoming, Arizona.
Group VIII—Colorado, New Mexico, Kansas, Oklahoma, Arkansas, Louisiana, Texas.

Your Committee believes the present districts are well selected and recommends that no change be made until the operation of the new arrangement shows the change to be desirable.

Your Committee recommends that nominations be made of one or more candidates for the vice-presidency of each district by the Sections Delegates Conference for that district and that these nominations be sent to the National Nominating Committee which will nominate the one who in its judgment is the best qualified for the office.

Your Committee further recommends that to the Nominating Committee as at present constituted (one member from each of the eight districts) there be added three members at large nominated by the Council and that the two junior past-presidents sit with the committee as advisers but without vote.

Your Committee agrees with the opinion expressed at the Council meeting in Pittsburgh that provision should be made for continuity in the Nominating Committee.

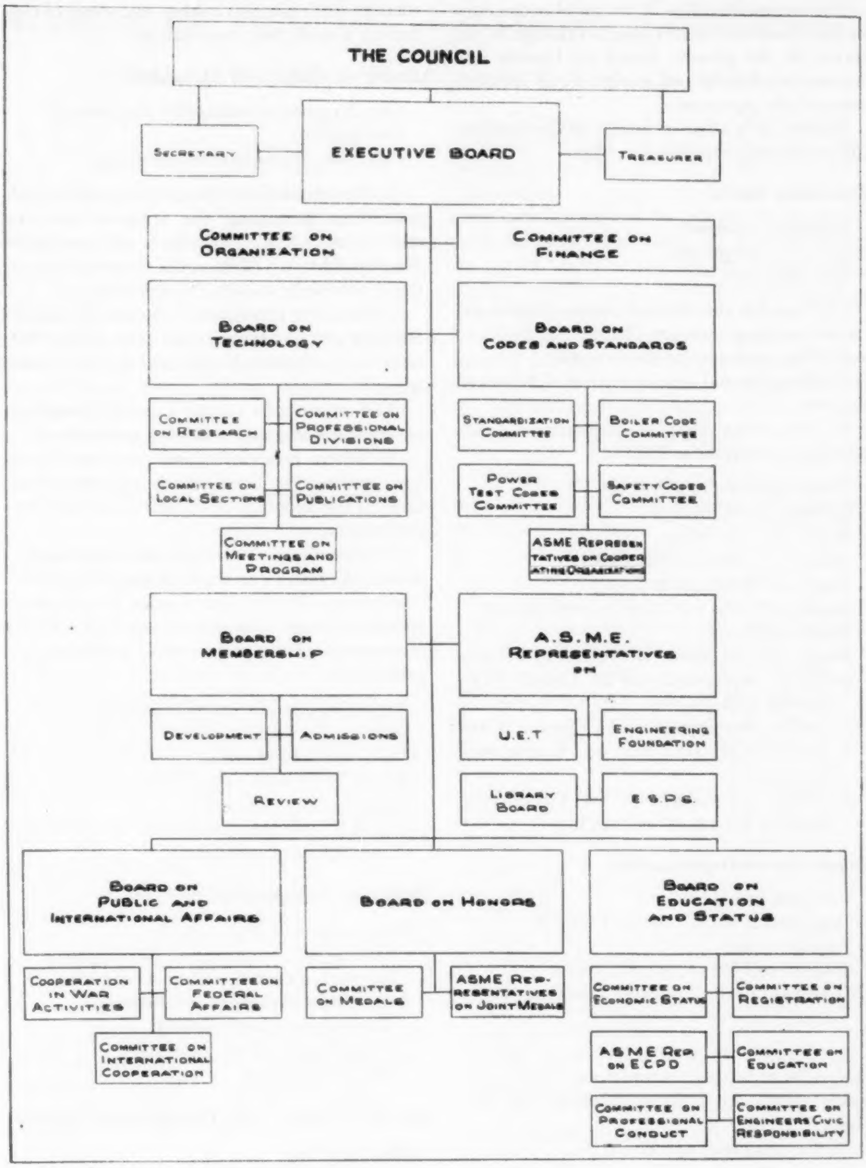
It is recommended that the elective members of the Nominating Committee be elected to serve two years, one half to be elected each year.

Your Committee recommends that no change be made in the method of electing Managers; but it does recommend that the name be changed to Director, which in the opinion of the Committee is the name most uniformly used in American practice to designate such office and duties.

Term of Office and Eligibility. Your Committee recommends that each district vice-president be elected for a two-year term and that he be eligible for re-election to serve a second term. Your Committee recommends that each director be elected for a four-year term and that he be ineligible for re-election as director but eligible for election as a vice-president.

(2) Committee Responsibility

In considering A.S.M.E. standing and special committees and having in mind the instruc-



tions to so lighten the burden on the Council as to leave both the Council and the Executive Committee more freedom to consider matters of broad-gage policy and to formulate long-term plans for the benefit of the Society, your Committee recommends the setting up of Boards of Control as shown on the accompanying chart; each Board to have jurisdiction over committees in its own field.

Your Committee believes that this type of organization will permit the Council to accept reports from the various Boards with confidence that the matters therein submitted have received thorough and conscientious consideration and that only questions of policy need the Council's attention and action, thus greatly expediting the work at meetings.

It will be noted that all existing operating committees would hereafter report to one of the Boards recommended. Since, however, the change is somewhat radical, your Committee believes and recommends that the Council should decide how many of these Boards of Control should be set up immediately. The Council may look to the Committee on Organization, intended to function as a constant check on proper organization and personnel, for advice as to the extension of the Board organization scheme beyond what is first set up.

The present Board on Technology has been continued by the Council for another year.

One of the first Boards to be set up at once, because of its importance, should be the Board on Codes and Standards to which would report the Committee on Boiler Code, the Power Test Codes Committee, Committee on Safety, the Committee on Dimensional Standards, and the A.S.M.E. representatives on A.S.A.

No change is contemplated in either the duties or responsibilities of important agencies of the Society such as Boiler Code and Power Test Code Committees. It is realized by your Committee that these two committees have a status unique in engineering and legal circles and it is very important that neither their prestige nor their responsibility be in the least curtailed. The function of the Board is intended to be that of responsible co-ordinating and screening agent to which is delegated authority from the Council to pass on matters handed up to it and to make recommendations for Council approval of codes and standards and for committee appointments within the jurisdiction of the Board.

The second Board to be set up at once could be the Board on Honors since no change in the status of the present Board on Honors and Awards is contemplated except in the appointment of the personnel.

Following is a list of Boards of Control and the committees reporting to them:

Executive Board

President, *chairman*
Two vice-presidents
Two directors.

(1) Acts for the Council in the interim between meetings (except changes in By-Laws and filling vacancies on the Council).

(2) Receives and acts on reports of Boards of Control.

(3) Supervises assigned committees. Reporting committees as follows:

Committee on Organization
Committee on Finance
Board on Technology
Board on Codes and Standards
Board on Membership
Board on Public and International Affairs
Board on Honors
Board on Education and Professional Status
A.S.M.E. representatives on United Engineering Trustees, Inc.
A.S.M.E. representatives on Library Board
A.S.M.E. representatives on Engineering Foundation
A.S.M.E. representatives on Engineering Societies Personnel Service, Inc.

Committee on Organization

Two past-presidents
One director chosen by the Council
President-elect
Chairman of Finance Committee
Chairman of Professional Divisions Committee

(1) Continually reviews personnel and organization of Boards, Committees, and of staff; makes pertinent recommendations to the Council.

(2) Reviews staff operation.

(3) Recommends committee appointments to the Council.

(4) Constitution and By-Laws.

Committee on Finance

Five members of the Society, one of whom is chairman.

Shall have supervision of the financial affairs of the Society, including the books of account.

For some years two members of the existing Council have been appointed to the Finance Committee. Your Committee recommends that this practice be discontinued thus relieving two Council members of the burden of attending Finance Committee meetings, believed to be no longer necessary.

Board on Technology

One member of Council, to act as chairman
Two members at large
Five other members who shall be the chairmen of Committees on Meetings and Program, Professional Divisions, Publications, Research, and Local Sections.

Recommends to the Council ways and means of effecting more consistent and logical co-ordination and correlation of the technological functions and activities of the Society and also to recommend to the Council procedures whereby the technical quality and scope of the Society's work may be enhanced.

Board on Codes and Standards

One chairman appointed by the Council
One director
Chairmen of committees reporting.

(1) Recommends to the Council policies and procedures governing the approval and adoption of A.S.M.E. standards and standards developed by A.S.M.E. under the procedure of the American Standards Association.

(2) Reviews procedures followed by standardizing and codifying committees of the Society and recommends approval by the Council.

(3) Recommends to the Council personnel for standardizing and codifying committees.

(4) Where procedures and personnel have been approved by the Council, recommends to Council the adoption of standards or codes for the Society.

(5) Co-ordinates, through its recommendations to Council, the work of the Boiler Code Committee, Power Test Codes Committee, Standardization Committee, and A.S.M.E. representatives on co-operating technical organizations.

Reporting committees as follows:
Standardization Committee
Boiler Code Committee
Power Test Codes Committee
Safety Codes Committee
A.S.M.E. representatives on co-operating technical organizations.

Board on Membership

One member of the Council
Chairman of Committee on Development
Chairman of Committee on Admissions
Reporting committees as follows:
Committee on Admissions
Committee on Development
Board of Review.

Board on Public and International Affairs

One chairman
One vice-president
One director
Two others appointed by the Council.

(1) Recommends to the Council policies and procedures for Society relations with public affairs and international relations.

(2) Supervises assigned committees:

Co-operation in war activities
(1) Co-operates with Army and Navy in war activities.
(2) Recommends policies to support defense activities in peacetime.

Committee on Federal Affairs
(1) Reviews proposed Federal legislation relating to advancing the art and science of engineering and recommends Society action thereon.
(2) Co-operates with Federal agencies (except Army and Navy) in matters relating to mechanical engineering

Committee on International Co-operation
(1) Recommends policies and procedures to promote co-operation with engineering professions of other nations.
(2) Supervises activities in international relations that are assigned to the Committee.

Board on Honors

One chairman
One vice-president
One director
Two others nominated by the Council.

(1) In accord with policies and procedures approved by the Council, nominates to the Council the recipients of honors, medals, and honorary membership.

(2) Reviews activities of joint medal boards and makes pertinent recommendations to the Council.

Reporting committees as follows:

Committee on Medals
A.S.M.E. Representative on Joint Medals

Board on Education and Professional Status

One chairman
One vice-president
One director
Two others nominated by the Council.

(1) Recommends policies and procedures by which the Society may improve engineering education, encourage the development of young engineers, foster study of the history of the profession, improve the status of engineers, co-operate in improving the standard for granting the legal right to practice, and maintain a high standard of ethical practice.

(2) Supervises assigned committees, as follows:

Committee on Status of the Engineer
Committee on Registration
Committee on Education
Committee on Professional Conduct
Committee on Engineers' Civic Responsibility
A.S.M.E. Representatives on E.C.P.D.

(3) Efficiency of Organization

The present headquarters staff headed by the Secretary has five department heads:

Ernest Hartford, acting for Secretary, membership, local sections, student branches, meetings, divisions
C. B. LePage, secretary to technical committees
G. A. Stetson, editor of publications
Frederick Lask, advertising manager, publications
D. C. A. Bosworth, controller and office manager

Your Committee believes and urges that several competent additional assistants should be sought whose age shall in no case be over forty and preferably younger.

Your Committee realizes that while the war continues it will be difficult to find good men, but at least the field can be thoroughly canvassed. The end of the war is certain to make available plenty of material in younger men who have contributed notably to the war effort either in uniform or in industry.

(4) Responsibilities of the Secretary of the Society

Your Committee has discussed at length the recommendation that serious consideration be given to changing the title of the Secretary, perhaps to Executive Vice-President, with the thought that more prestige would adhere to that title than to the present one.

Your Committee believes that the title and

use on all official papers of "Secretary, The American Society of Mechanical Engineers" will carry with it all the prestige necessary, and that the use of the simpler title for nearly 64 years has honored it to an extent that makes a change undesirable unless the objectives sought prove unattainable otherwise.

Your Committee feels that the Secretary has now all the necessary power to carry out the wishes and administer the decisions of the Council and that proper preparation of agenda with advance information to members wherever practicable will permit the necessary business of the Society to be transacted with speed and efficiency, leaving time for discussion of current problems and forward planning.

G. L. Knight, *Chairman*
Clarke Freeman
G. E. Hulse
K. M. Irwin
H. R. Westcott
D. Robt. Yarnall

Committee on Society Organization Structure

1945 A.S.M.E. Mechanical Catalog and Directory Out

700 Pages of Information

The thirty-fourth annual A.S.M.E. Mechanical Catalog and Directory, 1945 edition, to be published October 1 by The American Society of Mechanical Engineers, will be distributed to A.S.M.E. members during October.

In its catalog section, manufacturers describe and illustrate their products that are of interest to mechanical engineers. This section is followed by a Directory which gives the user a practically complete and authoritative index to manufacturers of metals and alloys, power-plant equipment, power-transmission equipment, instruments, materials-handling apparatus, aircraft power plants and instruments, foundry and machine-shop equipment, heating, ventilating, and air-conditioning equipment, electric motors and controls, equipment for process industries, pumps, fans, compressors, and many other types of mechanical apparatus. A page-reference system in the Directory ties up with the catalog, providing descriptions of the desired machine or equipment.

According to the editors of the volume, it is the only book which covers the field of mechanical engineering so thoroughly.

A 16-page insert describing all A.S.M.E. publications, such as power test, boiler construction, and safety codes, American Standards, fluid meters, engineering biographies, bibliographies, research reports, and manuals, is included in this volume for the ready reference of A.S.M.E. members and other users.

R.A.F. Air Marshal Honored

The John Jeffries Award, which is given annually by the Institute of the Aeronautical Sciences for notable contributions to aero medical research, has been awarded for 1944 to Air Marshal Sir Harold E. Whittingham, Director-General of Medical Services of the Royal Air Force.

Actions of A.S.M.E. Executive Committee

At Meeting Held at Headquarters, Aug. 25, 1944

A meeting of the Executive Committee of the Council of The American Society of Mechanical Engineers was held in the rooms of the Society on August 25. President Gates presided, and there were present: W. J. Wohlenberg vice-chairman, A. C. Chick, and W. G. Christy, of the Committee; J. J. Swan and G. L. Knight (Finance), W. M. Sheehan (Professional Division); Alex D. Bailey, presidential nominee; C. E. Davies, secretary, and Ernest Hartford executive assistant secretary. Paul B. Eaton, former member of the Council, was also present.

The following actions were of general interest:

Society Organization

The report of the Committee on Society Organization Structure was discussed and approved in principle. Copies were ordered sent to the Council, chairmen of standing committees, and local sections for comment, and to the Committee on Constitution and By-Laws with a request that necessary changes in the Constitution be formulated for consideration of the Council at its meeting of Nov. 26, 1944. The President was requested to discuss the report on the "President's Page" (see page 684) in Mechanical Engineering, and to convey the report to the Local Sections conferences with a letter explaining its purpose and background.

[The complete report will be found on pages 674–677 of this issue.—Editor.]

The report will be presented at the Business Meeting of the Society, Nov. 27, 1944.

Cancellation of Fall Meeting

The Committee noted a communication from the Assistant Director of the Office of Defense Transportation expressing appreciation of the co-operation of the Society by postponing the Cincinnati Fall Meeting.

Manufacturing Engineering Committee

It was reported that Herbert B. Lewis, executive secretary of the Manufacturing Engineering Committee since its inception, entered the employ of the Lukens Steel Company, and R. B. Smith, formerly with the International Text Book Company, had been appointed to handle the work under the supervision of Mr. Lewis. A report of the committee was noted.

Contributions

The Secretary reported that the Committee on Dues-Exempt Members' Contributions had solicited voluntary contributions from the members of the dues-exempt group. From 85 contributors $2027.50 had been received to date. The amount includes $500 from Lewis M. Ellison, of Chicago, Ill., in memory of his brother, Albert O. Ellison.

O.P.R.D. Policy Committee

The Secretary reported that he had been asked to serve on the Policy Committee of the Office of Production Research and Development, representing the Society.

Distinguished Service Award

The Secretary reported that Major General L. H. Campbell, Jr., Chief of Ordnance, advised, by written communication, that the Ordnance Department was grateful for the "outstanding contributions The American Society of Mechanical Engineers has made to Ordnance progress in this war" and "to attest the appreciation of the Department for the splendid services of the Society, I wish to present to the Society the Ordnance Distinguished Service Award." The award consists of a diploma bearing the traditional seal of the Department and is awarded "in recognition of scientific and engineering achievement."

E. Bruce Ball

The Secretary reported the death, in June, 1944, of E. Bruce Ball, honorary member of the Society and former president of The Institution of Mechanical Engineers.

Appointments

The following appointments were approved:

Library, P. H. Hardie (four years).

Power Test Codes: No. 3 on Fuels, R. A. Sherman, chairman, O. F. Campbell, H. C. Carroll, T. D. Delbridge, F. G. Ely, S. B. Flagg, F. W. Keator, W. Nacovsky, E. X. Schmidt, W. A. Selvig.

No. 17 on Internal-Combustion Engines, Lee Schneitter, chairman, W. L. H. Doyle, M. A. Elliott, C. W. Good, and W. F. Joachim.

Tellers of Election, 1945 officers, G. L. Knight, Erik Oberg, S. D. Spring, R. L. Sackett, alternate.

Joint Conference Committee, Subcommitte, on Student Membership Requirements, F. E. Lyford.

E.C.P.D. Committee on Professional Training, O. B. Schier 2nd.

Polish-American Engineers Organize to Aid Rehabilitation

At the meeting of the representatives of Polish-American Engineering and Technical Societies, held in Chicago in July, 1944, a Polish Technical Societies Council was formed to aid in Poland's postwar educational and industrial rehabilitation. Representatives from Chicago, Detroit, Philadelphia, and New York were present.

J. S. Kozacka, member A.S.M.E., of the mechanical-engineering department of Illinois Institute of Technology, Chicago, was elected president, and Frank Nurczyk, manager of the Polish-American Business Men's Association, Chicago, is the new secretary-treasurer.

The group is co-operating with the Polish refugee engineers in England and Canada in devising plans for postwar activities to aid industries and educational institutions by providing consulting service and qualified engineers and technicians.

At the present time the group is registering all engineers who would be willing to offer services either to Polish government or industry, or who would be available for service with the American industry in the future export-import activities.

1944 A.S.M.E. Annual Meeting Program Designed to Complete War Production and Develop Reconversion Problems

Headquarters, Hotel Pennsylvania, New York, Nov. 27–Dec. 1

THE 1944 Annual Meeting of The American Society of Mechanical Engineers will be held in New York, N. Y., Nov. 27–Dec. 1, at the Hotel Pennsylvania. The postponement of the Fall Meeting which was to have been held at Cincinnati the first week in October will in some respects enhance the quality of material to be presented at the Annual Meeting. This postponement occurred because the Director of the Office of Defense Transportation requested it, but he agreed at the same time to the holding of the Annual Meeting as a "localized" project. Of course the membership of the Society centers largely around New York where more than 25 per cent of the members are located; and 50 per cent of the membership is within a 200-mile radius. Furthermore, many members residing at greater distances frequently come to New York, Washington, or nearer points on essential war business and can in some cases also include the Annual Meeting on the same trip.

Emphasis to Be Laid on War Production

Since the war began practically all A.S.M.E. meetings have had greatly increased attendance and it is felt that the reason lies in the fact that the programs in every case were directed toward increasing production of war material. Last year the size of the program as well as attendance broke all records in the Society's history. The aim of the program makers of the 1944 Annual Meeting will be to present a program of superlative quality dealing with completing the war-production job and preparing the way for reconversion.

The successful conduct of the 1943 meeting at the Hotel Pennsylvania has encouraged the Committee to renew its arrangements with that hotel for the forthcoming meeting. Members attending will find the facilities have been further improved, so that there will be adequate opportunity for the successful conduct of the program.

Society Affairs to Be Discussed on Sunday

In accordance with the practice of the last few years, Sunday will be utilized for meetings of the Sections Delegates, Executive Committee of Council, and the general informal discussion of Society policies in which members of all committees are invited to participate.

Members of Council and Sections Delegates will have luncheon together and following the luncheon the Council will convene in formal session while the Sections Conference will continue independently.

Monday Luncheon to Feature Prominent Speakers

On Monday at luncheon the regular program will begin with outstanding speakers whose names will be announced in the completed program which will appear in the November issue of MECHANICAL ENGINEERING. Last year and in 1942 the speakers of this luncheon were Igor Sikorsky and Charles F. Kettering and it is planned to have equally prominent speakers this year. After the luncheon the afternoon will be devoted to the discussion of the speakers' subjects.

The official business meeting of the Society will follow this session and will start at 4:00 p.m. at the Hotel Pennsylvania.

Technical Program Being Developed

Sessions have been requested on Applied Mechanics, Aviation, Fuels, Heat Transfer, Hydraulics, Industrial Instruments, Management, Metals Engineering, Oil & Gas Power, Steam Power, Production Engineering, Railroad Engineering, Rubber and Plastics, Wood Industries, Education and Training, Metal Cutting, Furnace Performance, Mechanical Springs, and all requests are not yet in.

The completed program giving the layout regarding place and time of all sessions will appear in the November issue of MECHANICAL ENGINEERING and an announcement will be sent to members within a radius not greater than Washington or Boston about November 1. Members beyond the 200-mile distance from New York who would like to receive a copy of this special announcement are requested to write the Secretary to that effect prior to November 1.

Other Luncheons Planned

There will be a Management luncheon as usual, probably on Tuesday, and a Wood Industries luncheon, probably on Wednesday. On Wednesday also there will be the usual student luncheon.

Official Notice
A.S.M.E. Business Meeting

THE Annual Business Meeting of the members of The American Society of Mechanical Engineers will be held on Monday afternoon, November 27, 1944, at 4:00 p.m. at the Hotel Pennsylvania, New York, N. Y., as a part of the Annual Meeting of the Society.

Make Your Reservations Early

The Pennsylvania Hotel has 2200 rooms, but nevertheless it will be wise to get hotel reservations in promptly after reading this announcement. Arrangements have been made with the management of the hotel so that reservations which come in too late to be cared for will be handled by one of the several other hotel's within a block of the meeting headquarters.

The Power and Mechanical-Engineering Show

Whereas the Society has no connection with the management of the Power and Mechanical-Engineering Show which is held biannually, members attending the Annual Meeting will be interested to know that this show is scheduled to be held at Madison Square Garden in New York City the same week as the Annual Meeting.

E.C.P.D. Plans to Survey and Accredit Technical Institutes

FOR ten years the accrediting of degree-granting engineering colleges has been a major activity of the Committee on Engineering Schools, one of the standing committees of the Engineers' Council for Professional Development. The list of accredited curricula has been formally adopted by the national societies which comprise the Engineers' Council as a basis for judging educational qualifications of prospective members and is in use by the examining boards in the 46 states which now have professional-engineer registration.

A second field of technical education, whose importance has been emphasized by the serious shortages of qualified men developed by the war effort, is at the technical-institute level. After several years' study by a committee under the chairmanship of Dean H. P. Hammond, member A.S.M.E., of The Pennsylvania State College, a plan to inspect the work of technical institutes has been presented to the Engineers' Council for Professional Development and approved by the constituent societies. It is expected that the accrediting of educational programs of the technical-institute type will be carried out in a manner similar to that used for the engineering colleges. A new general accrediting committee with Dean Hammond as chairman is in the process of formation. This group, which will include representatives of industry and of the various types of institutions offering technical-institute courses, will function for the present as a subcommittee of the standing Committee on Engineering Schools.

The subcommittee report defined technical-institute courses as those preparing technical aides or assistants to professional engineers and included in the scope of the proposed accrediting movement junior technical colleges, exten-

sion courses, evening schools, correspondence schools, industrial institutes, and proprietary schools as well as the traditional technical institutes. It is expected that the accrediting program, which will meet a serious need and provide recognition of important educational work which has long deserved such recognition, will be inaugurated this fall. An accredited list in this field will be of tremendous value both to high-school students planning postgraduation study and to industrial employers seeking qualified candidates.

Material for Electronics Training Course Now Available

DESIGNED to give in a clear understandable manner the basic principles and applications of electronics in industry, a new ten-part training course covered by sound slide films, lesson books, quiz books, and an instructor's manual has been prepared by Westinghouse.

Although designed primarily for Westinghouse employees, the material has been made available to others at reproduction costs because of requests from engineering groups and individuals interested in electronics.

It is recommended that twenty hours should be allowed for the full 10-part course—two hours for each part, with classes held one night each week, thus giving class members a chance for review and supplemental reading.

Subjects Covered

Subjects covered by the course are as follows:

Part I Electronics and the electron theory of matter; electron movement during current flow through metal conductors; emission of electrons and their controlled flow through vacuum and gases.

Part II Theory of current rectification by vacuum tubes; kenotrons—high-voltage, low-current rectifiers.

Part III How gas in a tube neutralizes space charge; gaseous rectifier tubes.

Part IV Electronic amplification.

Part V Electronic generation of high-frequency alternating currents.

Part VI Electronic oscillators for radio and carrier-current transmission.

Part VII Basic circuits for electronic control.

Part VIII Industrial applications of electronic regulation.

Part IX Industrial applications of electronic control.

Part X Electronic conversion of light into electricity—and electricity into light.

Material for the Course

Sound slide films and records for the ten lessons give clear visual explanations of basic theory and applications. (For use with standard sound slide-film equipment.) Ten lesson books in handy pocket size, reproducing the subject matter of each lesson, are provided for each member of the class. These afford a convenient means of review and supplemental study. Pictorial quiz books are supplied for mid-course and final review of the subjects covered, and an instructor's manual giving suggested classroom procedure is provided with the complete course. Informative booklets on industrial electronic equipment are supplied covering ignitron rectifiers, high-frequency heating, resistance welding, power-line carrier rototrol, sealed ignitron, and electronic-tube data sheets.

Carnegie Tech Receives Ordnance Distinguished Service Award

AT the Forty-first Commencement Exercises of the Carnegie Institute of Technology, held here on Sunday, August 27, Major General Charles T. Harris, Jr., Commanding General, Aberdeen Proving Ground, Maryland, presented the Institute the Ordnance Distinguished Service Award. Dr. Robert E. Doherty, president of Carnegie Tech, accepted the award.

In his presentation address General Harris commented upon the outstanding work performed by Carnegie for the Army, both prior to and following the entry of the United States into the present war. He stated that the award was in recognition of the notable technical and scientific contributions which the Institute had made toward the advancement of Army Ordnance matériel.

Annual Water Conference in Pittsburgh, Pa., Oct. 30-31

THE Fifth Annual Water Conference of the Engineers' Society of Western Pennsylvania will be held at the William Penn Hotel, Pittsburgh, Pa., on October 30 and 31, according to an announcement by H. M. Olson, chairman. The program will comprise the following speakers and subjects:

M. J. Shoemaker, chief chemist, Research Products Corporation, Madison, Wis., "Two Zone Methods for Operating Hydrogen Exchangers for Boiler Feedwater Operation."

M. E. Gilwood and V. J. Calise, research chemical engineers, The Permutit Company, New York, N. Y., "Recent Experiences in Demineralizing Water."

A. E. Griffin, assistant director, technical service division, Wallace & Tiernan Co., Newark, N. J., "Removal of Ammonia by Chlorination."

H. L. Kahler, director of research, W. H. & L. D. Betz, Philadelphia, Pa., "Once-Through and Recirculating Cooling-Water Studies."

L. P. Sudrabin, consulting engineer, Dayton, Ohio, "Cathodic Protection of Steel Equipment Submerged in Water."

P. J. Stein, general foreman of water supply, Koppers United Company Plant, Cobuta, Pa., "Filtration, Softening, and Boiler Feedwater Treatment."

H. W. Howe, chief engineer, Koppers United Company Plant, Cobuta, Pa., "Service Water Facilities."

F. B. Varga, assistant superintendent of processes, Koppers United Company, Butadiene Division, Rubber Reserve Company, Cobuta, Pa., "Effluent Treating Facilities."

E. M. Griffith, assistant master mechanic, Republic Steel Corporation, Youngstown, Ohio, "Water-Treating Problems in Steel Mills."

L. B. Miller, chairman of the Water Committee, Technical Association of the Pulp and Paper Industry, Ambler, Pa., "Water in the Paper Industry."

R. D. Hoak and C. J. Lewis, Industrial Fellows, Mellon Institute, Pittsburgh, Pa., and W. W. Hodge, dean of engineering, University of West Virginia, Morgantown, West Va., "Lime and Limestone in Waste-Pickle-Liquor Treatment."

N. P. Rand, vice-president, Norwood Filtration Company, Florence, Mass., "Ozone as a Water Sterilizer."

H. R. Hay, chemical engineer, Philadelphia Quartz Company, Philadelphia, Pa., "The Use of Silicates for Coagulation."

A.S.T.M. Forms Committee on Adhesives

A NEW technical committee has been organized by the American Society for Testing Materials to function in the field of adhesives. This committee, having been authorized by the Society some months ago, was formally organized at a meeting at A.S.T.M. Headquarters in Philadelphia late in June, at which the technical men who are serving as members of the committee, representing leading producers and consumers of adhesives, discussed problems in connection with the scope, important activities which needed to be started, and personnel.

T. R. Truax, principal wood technologist, U. S. Forest Products Laboratory, Madison 5, Wis., who had been appointed temporary chairman of the committee, presided at the meeting. Other temporary officers who will serve are P. H. Bilhuber, member A.S.M.E., Steinway and Sons, New York, vice-chairman; and Henry Grinsfelder, senior engineer, Resinous Products & Chemical Co., Philadelphia, secretary.

A preliminary statement of scope of the committee is as follows:

The formulation of specifications, methods of test, and definitions of terms pertaining to adhesives, including animal, vegetable, mineral, and synthetic types.

Following the setup of most A.S.T.M. technical committees, a number of subgroups are being appointed to be responsible for specific projects in this field of activity. A list of the subcommittees with some indication of their responsibilities follows:

I Subcommittee on Strength Tests (M. H. Bigelow, chairman). Shear, tension, compression, torsion, vibration, etc.

II Subcommittee on Analytical Tests (Leonard Repsher, chairman). Viscosity, acidity, fillers, etc.

III Subcommittee on Tests for Permanency (F. J. Wenmer, chairman). Moisture, temperature, chemicals—oils, salt, etc., microörganisms, etc.

IV Subcommittee on Working Qualities (C. B. Hemming, chairman). Working life, assembly time, rate of setting, gluing pressure, etc.

V Subcommittee on Specifications (Gerald Reinsmith, chairman). Synthetic resins, starch, animal, casein and vegetable proteins, cellulose, minerals, rubber, bituminous, etc.

VI Subcommittee on Nomenclature and Definitions (G. M. Kline, chairman).

1944 Local Sections Group Conferences

Group	City	Place	Date	Presiding Officer
I	Hartford	Bond Hotel	September 8–9	R. M. Scott
II	New York	A.S.M.E. Headquarters	September 20	H. C. R. Carlson
III	Philadelphia	Philadelphia Engineers' Club	September 15–16	F. W. Miller
IV	Atlanta	Ansley Hotel	September 22–23	F. J. Reed
V	Akron	Mayflower Hotel	October 6–7	J. G. Martin
VI	Peoria	Marquette Hotel	September 28–29	W. W. Babcock
VII	Los Angeles	Los Angeles Athletic Club	October 13–14	B. T. McMinn
VIII	Dallas	Baker Hotel	October 9–10	G. H. Woebling

TIME: 9:30 a.m. for all Conferences.

Among the Local Sections

Raleigh Section Inspects Edwards Co. Plant

THE program of the Raleigh Section on July 29 consisted of an inspection tour of the Edwards Company plant at Sanford, N. C., a barbecue chicken supper at the Sanford Golf Club, Sanford, and concluded with a brief business session.

Guests included members of the staff of the Edwards Company, student members of the A.S.T.P. at State College, and wives of the Section members.

J. Kenneth Salisbury Speaks at San Francisco Section Meeting

At a well-attended joint meeting of the San Francisco Section and members of the A.I.E.E., held in the Pacific Gas & Electric Company Auditorium, 245 Market Street, San Francisco, Calif., on July 25, J. Kenneth Salisbury spoke on the subject of "The Gas Turbine—Its Characteristics and Potentialities." Mr. Salisbury, who is gas-turbine application engineer for the General Electric Company, Schenectady, N.Y., gave a historical review of this engine and presented charts and curves to illustrate its performance.

Schenectady Section Holds Two Dinner Meetings

A dinner was held at the Hotel Van Curler, Schenectady, N. Y., July 25, by the Schenectady Section, to welcome C. Concordia, Dr. C. J. Walker, and C. M. Gardiner, newly elected members of the Executive Committee. After the dinner, officers for the coming year were elected. On August 2, the Executive Committee and senior members of this Section honored R. M. Gates, president of the Society, at a dinner at the Hotel Van Curler, after which Mr. Gates gave an informal talk on some of the problems of the Society. A discussion period followed.

Over 800 in Attendance at Special Dinner Meeting, Southern California

Four hundred members and guests attended the special dinner meeting held by the Southern California Section on July 18, in the main ballroom of the Elks Club, Los Angeles, Calif. In addition to the dinner guests, 400 to 500 afterdinner guests were also present to hear J. Kenneth Salisbury of the Turbine Engineering Division, General Electric Company, Schenectady, N. Y., speak later in the evening on the subject, "The Gas Turbine—Its Characteristics and Potentialities." Mr. Salisbury illustrated his subject in detail with a series of projected slides. The guests of honor at the speakers' table included: J. Kenneth Salisbury, speaker of the evening; S. E. Gates, Southern California district manager of the General Electric Company; George L. Sullivan, dean of College of Engineering, University of Santa Clara; C. D. Gard, president of California Natural Gasoline Association, and Paul Johnson, president, Los Angeles Section, A.I.E.E.

Gas Turbine Explained at Western Washington

The basic features of the gas-turbine plant were given by J. K. Salisbury, gas-turbine application engineer for the General Electric Company, Schenectady, N. Y., at the August 4 meeting of the Western Washington Section. Mr. Salisbury presented charts and curves to illustrate how the performance of the gas turbine varies with changes of pressure, temperature, cycle, and mechanical efficiencies of the component parts. He explained not only its probable usefulness, but also its limitations.

AT THE DINNER PRECEDING THE MEETING ON JULY 18

Junior Metropolitan Group Plans Active Year

First Meeting Gives Promise of Successful Season

THE Junior Group of the Metropolitan Section has planned what they hope is to be a very diversified and interesting program for the forthcoming year. With everything from humorous movies to the latest technical subjects, the program as contemplated is quite unusual and beneficial.

Smoker at George Washington

In an effort to get the season's activities off with a bang, the first meeting was a smoker held on September 26 at the Hotel George Washington. The meeting was designed to attract students from the local colleges. The meeting consisted of dinner, movies, and a song session which put Sinatra and Crosby to shame. It proved an opportunity for everyone to get together and make new friends while renewing acquaintance with many of the old.

Electric Air Cleaning

The second meeting, which will be held on October 24, will be the first of the technical meetings and the subject is entitled "Electric Air Cleaning for Industry." The guest speaker will be Mr. Jean Fitz of the Westinghouse Electric and Manufacturing Company who is a recognized authority on this subject. The session will be enhanced by a blackboard demonstration and discussion.

Lubrication and Fuel Problems in Aviation

On November 21st a representative of the Aviation Research Laboratories of the Socony Vacuum Oil Company will present a talk on Lubrication and Fuel Problems of the Aviation Industry. This meeting will be of particular interest to aeronautical as well as petroleum engineers. There are many unusual problems in the aviation field that every engineer would like to hear about. We all know something of the perplexities of lubricants and consequently can gain considerable information by attending this meeting.

Other Events

Other events will be the business meeting in January as well as a nontechnical speaker in February. It is quite possible that the program this year will include an open forum of Junior speakers. While a program of this type is relatively new it should prove nonetheless interesting. It is planned to have outside speakers brought to New York so that Juniors will be able to get the viewpoint of men in other sections of the country who are in varied phases of industry.

Everyone Welcome

All of these meetings will be announced from time to time in local bulletins. The Junior Group would like to extend a cordial invitation to all members, student members, and friends to attend these meetings.

CHARLES H. CARMAN, JR., *Chairman,*
Publicity Committee, Junior Group,
A.S.M.E. Metropolitan Section

With the Student Branches

Patents and Engineering Discussed at California Tech Branch

AT the August 1 meeting of the CALIFORNIA TECH BRANCH, members met to hear J. Calvin Brown talk on the subject of "Patents and Engineering." Prior to Mr. Brown's comments, officers for the new term were elected as follows: C. J. Woodard, chairman; Larry Fuller, vice-chairman, and A. J. Acosta, secretary-treasurer.

UNIVERSITY OF CALIFORNIA BRANCH held its first meeting of the summer semester on August 9, at which Basil Garrett, chairman, appointed the following committees: Program, Frank Klock, chairman, John Anderson, David Brenner, and Gunther Balee; publicity, H. W. Grebe, chairman, and John Clawson. Chairman Frank Klock of the program committee, then outlined the program scheduled for the semester, which tentatively included various inspection trips, a discussion of the engineering profession by Dr. Woods, and comments by Mr. Duke, an instructor at the University of California, on engineering organization. After the business session, Mr. Murphy, honorary chairman, explained the purpose and value of becoming members of the A.S.M.E.

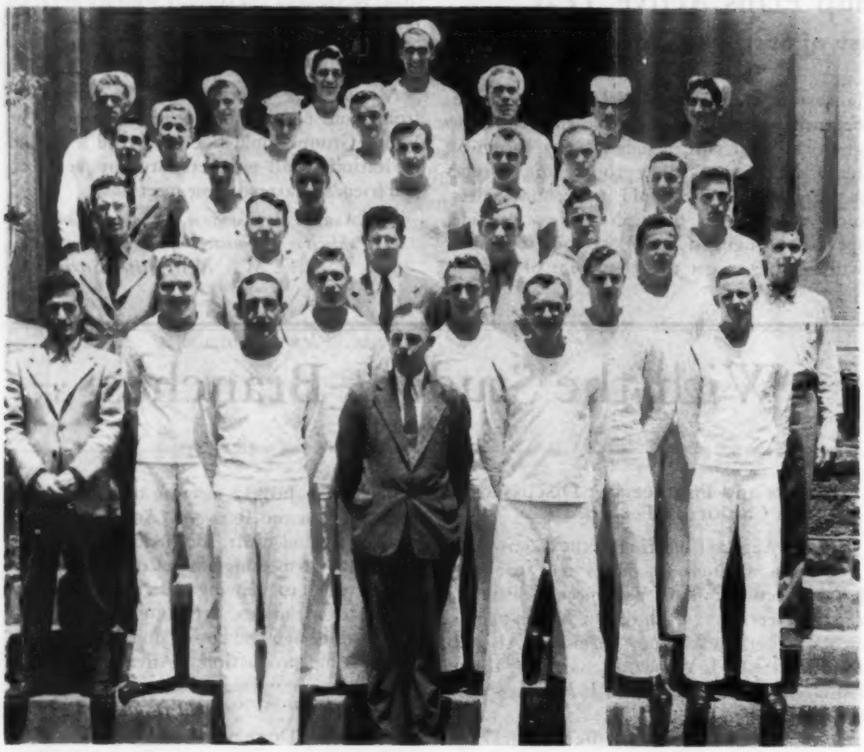
Dan J. McQuaid, consulting engineer, Denver, Colo., gave an extremely interesting lecture on his "Sun-Va" projection drawing machine, at the July 12 meeting of the UNIVERSITY OF COLORADO BRANCH. An informal discussion concluded Mr. McQuaid's comments.

The July 26 meeting of the CORNELL BRANCH was devoted to viewing a series of Chrysler Corporation movies, depicting the technical aspects of design and conversion of machinery for wartime production. After the movies, plans for the new semester's activities were discussed.

Members of DUKE BRANCH on July 19 viewed an interesting motion picture entitled, "Dial Indicators and Dial Indicator Gages." Prior to viewing the film, a short business session was held. This Branch met again on July 25, at which meeting Merill Isenhour was appointed social chairman. At the August 8 meeting of this Branch, Professor Lewis spoke at length on modern warship armament. Plans were also formulated for an inspection trip through the aircraft-parts plant at Sanford, N. C.

Officers for the coming semester were elected at the July 21 meeting of the KANSAS UNIVERSITY BRANCH, as follows: R. F. Maurer, chairman; Walter T. Sieguist, vice-chairman; Floyd H. Davis, secretary, and Willard G. Widder, treasurer. A series of discussions was then held on the types of programs desired by the members during the forthcoming term.

OF THE SOUTHERN CALIFORNIA SECTION OF THE A.S.M.E.



A.S.M.E. STUDENT BRANCH AT VILLANOVA COLLEGE

Maryland Branch Learns of Economic Aspects of Engineering

MARYLAND BRANCH met for its first meeting of the summer semester on July 18, with members of the A.S.C.E., A.I.E.E., and A.I.Ch.E., to hear Dr. Gruchy give an interesting account of "Economics in Engineering." The combined student branches met again on August 8, at which meeting the guest speaker was Mr. Michel of the U. S. Bureau of Ships, who spoke on the subject of "Vibration Trouble Shooting on Shipboard."

The featured speaker at the July 31 meeting of NEW HAMPSHIRE BRANCH was Professor Cortez of the English department. Professor Cortez spoke at length on the preparation of student papers, during the course of which members received numerous constructive suggestions. After the lecture, Al Harding was awarded a certificate for meritorious services rendered the A.S.M.E.

The motion picture, "This Plastic Age" was viewed by members of the NEW YORK UNIVERSITY BRANCH (DAY), at its first meeting of the summer semester on July 20. The picture described the process of manufacturing plastic, together with its diversified usages. Members of this Branch met again on August 3, at which time the motion picture "Die Casting" was shown. This picture depicted the production methods, equipment, and wide application of die casting.

On July 26 members of the NORTHEASTERN BRANCH met to enjoy two motion pictures, "Thrill Hunter," and "Years of Progress," lent through the courtesy of Wilding Pictures, Inc., Detroit, Mich. At the annual smoker held by this Branch on July 31, Prof. David Fisher, of the mechanical-engineering department of Tufts College, gave an interesting talk on the co-operative fuel-research engine. Prior to Professor Fisher's remarks, members viewed the U. S. Steel Corporation motion picture, "To Each Other," which depicted the extensive production and expansion program now being carried out by the corporation.

Industrial Water Supply, Conservation Feature of Summer Meeting Program at Ohio

The third meeting of the summer semester of the OHIO STATE BRANCH on July 14 was devoted to a series of motion pictures, which included a film demonstrating the possibilities of modern high-speed photography, a picture depicting the Army's new "Tank Destroyer," and the first commercial movie produced in 1903 entitled, "The Great Train Robbery." Dean MacQuigg featured the July 28 meeting of this Branch, speaking on the subject of "Water Supplies and Water Conservation." After quoting the vast quantities of water required to manufacture pig iron, steel, and the like, he suggested that new underground water supplies be tapped, old aquifers recharged, and waste water and water usage in general be controlled by law. This Branch met again on August 11, to hear Professor Beitler give an excellent review of the A.S.M.E., the activities of its various divisions, as well as the purpose and value of its meetings where constructive papers are presented and discussed. He also reported that on June 30, 1944, there were approximately 17,000 active and 900 service members enrolled in the Society.

An enthusiastic audience heard Dr. H. J. Anderson give an exciting account of his boat trip across the perilous fork of the Salmon River, Idaho, at the first regular meeting of OREGON STATE BRANCH on July 21. Dr. Anderson, who supplemented his lecture by colored motion pictures taken on the trip, is understood to be the seventh person ever to perform this trip successfully. He outlined in detail the type of boat necessary and preparation for such an expedition, as well as methods employed while operating on perilous waters.

Charles L. Allen, honorary chairman of PENNSYLVANIA BRANCH, recently reported several meetings held by this Branch. At two meetings between May 15 and June 15, motion pictures were shown depicting how aluminum shapes are formed from sheets or strips, and methods of applying stock shapes to aircraft requirements. On July 17, members of this Branch also viewed a motion picture describing the Bell development of the helicopter, lent through the courtesy of Bell Aircraft Company. This Branch met jointly on August 2, with members of the A.S.C.E., A.I.E.E., and of the Industrial Engineering Society to enjoy the film, "Unfinished Rainbows."

Purdue Learns "What's New in Housing"

"What's New in Housing," was the subject chosen by Charles R. Deverall, at the first meeting of the summer semester of PURDUE BRANCH, on July 19. Mr. Deverall lectured on materials now being tested by the Purdue Housing Research Project, for use in low-cost prefabricated houses for persons with incomes of $2000 or less a year. A picnic on the Purdue picnic grounds was held on August 6 by members of this Branch, during the course of which some good snapshots were taken by Earl Borseth, expert photographer.

Some helpful advice to young engineers was given by Mr. Hiebler of the Houston Lighting & Power Company, at the July 21 meeting of

PICINIC OF A.S.M.E. STUDENT BRANCH AT PURDUE, AUGUST 6

Rice Branch. At the brief business session held the same evening, new officers were elected as follows: Chairman, J. H. Elder; vice-chairman, A. J. Chapman; secretary, J. B. Davis; and treasurer, J. H. Simpson.

After a short business session on July 26, members of Southern Methodist University Branch enjoyed a movie taken and shown by Honorary Chairman C. H. Shumaker, reviewing some of the Society's outstanding activities of the past several years.

Southern Cal. Meets With A.I.E.E.

Neil Hawkins was elected vice-president of University of Southern California Branch on July 19, succeeding Bob Morton, who has joined the armed forces. At the same time, committee heads were selected as follows: Wendle Haas and Don Stoneman—field trips; Sharon Moody—reports at meetings, and Al Graves and Kenneth Macleod—social activities. This Branch met jointly on July 28, with members of the A.I.E.E., to hear Captain John Hamilton, engineering officer, Army Air Corps, tell about his experiences in New Guinea, and give some interesting facts about Japanese planes and equipment. Plans for a field trip to an aircraft plant and a tentative beach party were discussed at the August 9 meeting of this Branch, while on August 16, members met to make final arrangements for the proposed beach party, scheduled to be held August 19.

Election of officers for the present term of the Stevens Institute of Technology Branch was held on August 8, with Siegfried Dankenbring, '45, chosen chairman; Andy Hoch, '45, vice-chairman; Henry Zimmermann,'46, secretary, and George Homewood, '46, treasurer. An organization meeting was held by the new board to formulate an efficient distribution system for the organization's monthly magazine. Trips and a social smoker were planned, as well as an A.S.M.E. student convention at Stevens, with representatives from the six major engineering colleges in the metropolitan area participating. It was also decided that Stevens men write and present papers, not entirely of a technical nature, at this student convention.

New officers were elected at the June 20 meeting of Tufts Branch, as follows: Chairman, Jay P. Clymer; vice-chairman, Robert K. Agar, and secretary-treasurer, R. Douglas Smith. Prof. David A. Fisher was re-elected faculty advisor and honorary chairman.

Tulane Branch Reviews Activities of Term Meetings

A résumé of activities of the Tulane Branch for the past semester was submitted recently by John A. Cochrane, chairman of the Branch. Mr. Cochrane reported that six meetings were held, during the course of which two highly important topics were discussed, namely, formation of a union between all engineering societies, and selection of an engineering editor to supervise publication of the school paper. Two interesting field trips also were reported—one to the Higgins Industrial Canal Plant, and one to the National A.S.M.E. Spring Meeting at Birmingham, Ala., April 3–5, attended by Prof. J. K. Mayer and fourteen members of the senior class in mechanical engineering.

A motion picture entitled, "How Steel Is Made," was enjoyed by members of Villanova Branch on August 14. A brief business session was held before the film was shown.

Virginia Polytechnic Branch on June 12 heard Prof. A. E. Bock of the mechanical-engineering department, speak on the subject of "Engineering Education, In Regard to Humanistic and Social Aspects." After a short business session on July 10, at which G. A. Main was elected treasurer and R. H. Timberlake, corresponding secretary, and a motion was adopted to form a softball team, members of this Branch viewed the Crane Company film "Piping Pointers." At the July 31 meeting, a movie entitled "Rockwood Sprinkler Company Presents Water Fog," was shown, which described the methods employed in fighting a fire. The August 5 meeting was devoted to a game of softball, at which the mechanical-engineering students defeated students of the chemical engineering class. On August 14, members of this Branch elected three officers as follows: G. R. Pucci, chairman, succeeding D. W. St. Clair; C. C. Critzos, vice-chairman, and H. P. Marshall, recording secretary, succeeding G. R. Pucci, after which a motion picture, "Power by Wright," was shown.

Yale Branch Maintains High Level of Student Engineering Papers

Student papers presented at four meetings of Yale Branch were reported recently by Leslie P. Mitchell, secretary of the Branch, as follows: July 25, "Weather Forecasting," by W. O. R. Korder; "Jet Propulsion," by R. W. Cornell; "Photography: Art and Science," by R. E. Henrich, and "Torpedoes," by E. T. O'Hara. August 2, "Open Hearth and Rolling Mill Processes," by H. M. Shattuck; "The New System," by F. D. Miller, and "John Paul Jones," by G. P. Anastacion. August 8, "Gas Turbines: The New Prime Mover," by W. A. P. Meyer; "The Battleship," by W. E. Dampier; "Finding a Job," by R. H. Bernstein, and "Slide Rules, New and Old," by J. D. Hopkins. August 15, "Our War Department," by H. R. Taylor; "The U. S. Navy's Salvage Training School," by T. F. Keating; "A History of the Development of Marine Engineering," by R. P. Tucker, and an unnamed paper by C. A. Zabriskie.

Van Leer Is Inaugurated as President of Georgia Tech

The inauguration of Blake Van Leer, member A.S.M.E., as president of Georgia School of Technology, Atlanta, Ga., took place on July 7. Joseph W. Eshelman, vice-president A.S.M.E., represented the Society at the inauguration.

The Seamless Steel Tube Institute Data Book

The "Seamless Steel Data Book," a looseleaf binder of 320 pages, $8^1/_2 \times 11$ in., has been issued by the Seamless Steel Tube Institute, Pittsburgh, Pa., from whom copies may be purchased.

CLINTON R. HANNA, INVENTOR OF DEVICE WHICH PERMITS MOVING ARMY TANKS TO FIRE ACCURATELY, POINTS TO EARLY MODEL OF STABILIZER HAVING TWO GYROSCOPES

(He later developed an improved stabilizer utilizing only one gyro. He calls this the "Anticipating gyro" because it goes into action as soon as the gun breech exercises pressure on it and corrects for movement before it can take place. The Westinghouse engineer won a citation from the W.P.B. for this invention which permits our Army tanks to fire accurately while in motion.)

President's Page

Organizing for Larger Responsibilities

WE recognize the challenge to our profession and the opportunity for service that our Society faces in the coming change-over from war to peace. As the avenues of our activity widen, improvements in organization and co-ordination are needed at local, regional, and national levels.

A special committee, appointed last November, has been working on plans for improvement of the structure of our Society. After extensive consideration and consultation with many other members, it has agreed upon a report which is printed on pages 674–677 of this issue of MECHANICAL ENGINEERING.

I wish to call attention especially to two important changes recommended in the report. One increases district responsibilities and assures each district direct representation on the Council. The other lightens the present burden on the Council in connection with committee reports, giving it more freedom to consider broad policies and long-term plans for the benefit of the Society.

1 It is recommended that each of the eight districts have a Vice-President of the Society, nominated by and responsible to that district. The Sections Delegates Conference for the district would nominate one or more candidates for Vice-President from that district, and the National Nominating Committee would present this nomination or choose among the several nominees thus submitted. Each Vice-President would be elected for a two-year term and be eligible for a second term.

2 It is recommended that the Council be authorized to set up six Boards of Control. Each Board would be responsible for considering the reports of several of the operating committees, with such co-ordinating and screening as it might find desirable, and for presenting the reports to the Council for approval. It would also make recommendations to the Council on appointments to the committees assigned to it.

Three of the Boards (Public Affairs, Honors, and Status) would be appointed entirely by the Council. On the other three Boards (Technology, Codes and Standards, and Membership) the chairmen of the committees reporting to each Board would make up a majority and would thus be brought together for co-ordinating purposes. The Executive Committee would become the Executive Board, receiving the reports of these six Boards and also of the Committee on Organization, the Committee on Finance, and the A.S.M.E. representatives on joint engineering committees.

It is not proposed that all these Boards be set up at once. The functions of our present Board on Technology would be expanded. The Board on Honors now exists under a slightly different name. The Board on Codes and Standards is recommended as the first new Board to be appointed.

Other recommendations are included, among them, additions to the headquarters staff, change of name of Managers to Directors, four-year terms for Directors with ineligibility to second terms (although they would be eligible for election as vice-presidents or other officers), and election of the Nominating Committee for two-year terms—one half being elected each year.

These recommendations, as described in more detail in the report, deserve the careful consideration of our members generally. The two most important departures from our traditional practice, which I have pointed out, have been carefully planned to adapt our organizational structure better to our present situation and needs.

(*Signed*) R. M. GATES, *President*, A.S.M.E.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit, personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

Research and Development Engineer. Now director manufacture war products. Thirty years diversified experience, textiles, machinery, power production and utilization, fuel, wood products. Can analyze, develop, organize, and direct. Wants permanent responsible connection growing industry. Age 54. Eastern states preferred. Me-860.

Creative Executive Engineer with civil and mechanical degrees who has developed new processes and mechanical designs seeks position requiring leadership. Extensive experience in cost reduction, economic investigations, and design supervision. Me-861.

Mechanical Engineer, degree, registered. Twenty years' experience, supervising installation, maintenance, operation of power-plant equipment, and other machinery. Some design. Adaptability, ingenuity, sober and open-minded. References. Available W.M.C. at once. Me-862.

Mechanical Engineer, age 47, over twenty years' experience design and construction, chemical plant and general piping, pressure vessels, heating, ventilating, air conditioning, plumbing, desires position of responsibility and permanence. Me-863.

Executive Engineer, thirty years' extensive diversified engineering experience in process industries including research, development, instrumentation, production, management inspection, sales management, personnel advertising, editing and research analysis, worth-while business contacts. Me-864.

Graduate Mechanical Engineer, 24, draft-deferred, two years' experience aircraft development and research testing involving design, directing shop personnel, conducting tests, interpreting results, compiling reports. Change from aeronautics desired; will consider, however. Me-865.

Graduate Mechanical Engineer, 30, executive and management ability; experienced in direction of research, design, production and control, safety, maintenance, plant layout. Experience also in manufacture of metallic powders. Metropolitan area preferred. Me-866.

[1] All men listed hold some form of A.S.M.E. membership.

Executive Engineer, graduate mechanical, age 42, capable of taking charge of manufacturing and sales. Broad experience covers design, products, engineering, sales management and promotion, systems, methods, production, and accounting. Can organize new plans, programs, and systems and has sense of imagination of value in future planning. Me-867.

Executive Engineer, 40, considered authority on tooling, product design, manufacture. Permanent connection as chief engineer, superintendent. Excellent past record, references. Me-868.

Works Manager, 46, mechanical engineer, with heavy machine-shop, foundry, and welding-shop experience. Me-869.

Wood Technologist, B.S., M.S., 31; seven years' industrial experience, broad background in all phases of wood manufacture and technology including bag molding, high-frequency bonding, compreg, and variable-density construction. Understands chemical aspects of wood utilization. Me-870.

POSITIONS AVAILABLE

Engineers. (*a*) Mechanical engineer able to handle important design responsibilities connected with product development covering broad field of high-grade consumer products. Must be able to conceive and execute sound practical designs and follow through development. Should have broad knowledge of manufacturing processes and keen realization of cost factors. (*b*) Refrigeration engineer with theoretical background and considerable practical experience in field of mechanical refrigeration. Should be able to undertake major phases of design and development of new line of refrigeration equipment. Middle West. W-4112-C.

Factory Manager, graduate mechanical engineer, experienced in precision shop production. Must be good executive and capable of directing plant of approximately 750 people. Any experience in forgings would be beneficial. $8000–$12,000 year. Upper New York State. W-4116.

Assistant Executive Engineer, 35–45, with background of industrial experience in manufacturing plants. General business and financial experience essential. Knowledge of Spanish desirable. $5600 year. Washington, D. C. W-4123.

Shop Superintendent for large machine shop for company building presses and special machinery. Plant employs 400 people. To $10,000 year. Northern New Jersey. W-4142.

Tool Engineer capable of determining best method for making various types of sheet-metal products. Will be required to design all necessary tools, dies, jigs, and fixtures and either procure them from outside sources or supervise their manufacture in shops. Must have thorough understanding and be experienced in tooling up for production of sheet-metal products, designing of all tools, dies, jigs, and fixtures necessary to production of these products, as well as ability to obtain results and maintain production schedules. $6000 year. Pennsylvania. W-4143.

General Manager, 40–50, to operate small steam railroad in foreign country. Prefer foreign experience but will consider man with diversified domestic work or logging railroad experience. $8000–$10,000 year. Interviews, New York, N. Y. W-4173.

Technical Editor or Manager capable of preparing technical bulletins, revising and editing textbooks on resistance welding, preparing standards and specifications for resistance-welding machines, etc. Apply by letter giving full details regarding qualifications, past experience in industry, educational background, and salary desired. Some traveling. Pennsylvania. W-4193.

Supervisor for drafting room. Must have had at least 10 years' experience in design and 5 years' practical toolmaking experience in addition to having supervisory experience and good engineering knowledge. Salary dependent upon applicant. New York, N. Y. W-4197.

Engineer, under 45, with maintenance experience in food or dairy industry and familiar with sanitary laws of states and municipalities. $4000–$5000 year. Headquarters, New York, with considerable traveling to various plants. W-4199.

Product Engineer for manufacturer of electrical wiring devices. Should be designer with proved record of accomplishment. Firm possesses farsighted management, varied production facilities, and ample capital to undertake and promote new products. Scope and opportunity of position are limited only by skill, imagination, and initiative of man. Apply by letter. New England. W-4208-B.

Mechanical Engineer, young, industrial experience not necessary, or an older experienced draftsman or designer for work consisting of designing special stainless-steel tanks and process equipment. Opportunity. Apply by letter. Salary open. Michigan. W-4209-DC.

Design and Development Engineers on automatic packaging machinery with pneumatic, hydraulic and electronic controls. Job includes board layout, experimental shop and field work, and ability to direct others in design and detail work. Salary about $7500 year. New York State. W-4213-CD.

Machine Designer with some experience in machine-tool, textile, or automatic-machinery industries. Experience in power plant or combustion field desirable. Will be required to design and develop new coal stokers, stoker parts, and coal pulverizers and later possibly

to supervise field installations and testing of equipment. Permanent. Salary open. New England. W-4228-B.

CHIEF ENGINEER, 35-50, graduate mechanical engineer from recognized engineering school or equivalent. Will be responsible for direction, co-ordination, and supervision of all engineering activities, including supervision and direction of machine design, research, and development. Experience in printing machinery or high-speed machinery preferred. Must have executive and administrative ability. Postwar opportunity. Salary open. New York, N. Y. W-4239.

MATERIALS HANDLING SPECIALIST, M. E. degree, 28-44, with 2 or 3 years' experience with management firm. Should be able to pick out weak points. Be qualified to carry through work. Must also be able to write up reports. Must have pleasing personality. \$6000-\$9000 year. Headquarters, New York, N. Y. W-4241.

ENGINEERS now working in industrial plants who can qualify as consulting engineers on reconversion problems. Postwar opportunity. \$6000-\$8000 year. Headquarters, Maryland. W-4264.

ENGINEERS. (a) Director of purchases, under 45, mechanical-engineering degree preferred. Must have successful record showing ability to organize and administer efficient purchasing procedures. Must have up-to-date working knowledge of all CMP regulations. \$6000 year. (b) Manufacturing superintendent, under 50, mechanical-engineering degree or equivalent, with good background of practical experience in production of wide variety of small mechanical parts. Must have ability to organize and get things done, and be capable of accepting full responsibility for maintaining production schedules and handling of personnel problems involved in managing plant. \$7500 a year. Permanent with good postwar opportunities. New York metropolitan Area. W-4276.

DEVELOPMENT ENGINEERS. (a) Mechanical graduates with diversified experience in development and design of power hoisting mechanisms, control mechanisms, etc. (b) Electrical graduates experienced in design and development of power applications, signal, and control devices, etc. Permanent positions with old-established organization manufacturing essential equipment in heavy-goods industry. AA-A1 rating. No reconversion problems involved. Company will pay placement fee. \$4000-\$6000 year. Ohio. D-1937.

STRESS ANALYST for work on helicopter project. Postwar possibilities. Salary open. Michigan. D-1969.

SALES ENGINEER, 25-35, technical graduate, mechanical or structural, for design and sales engineering. Products are mostly stainless steel used in high-temperature operations up to 2100 F, and in corrosion-resistant service at ordinary temperatures. Must be able to compute simple stresses and estimate weights. Some chemical and metallurgical knowledge desirable, but not essential. Duties will involve estimates, quotations, technical correspondence, and some sales contacts with customers. Position is permanent with old-established company and offers excellent prospects. Write giving training, family status, and salary expected. Salary open. Detroit. D-1976.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after October 25, 1944, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ALBANO, RAY J., Chicago, Ill.
ANDERSON, MARION M., Moline, Ill.
ASPINALL, A. R., Bolton, Lancs., England
ASTLEY, WAYNE C., Philadelphia, Pa. (Re)
BENNETT, JAS. W., Arlington, Va. (Re)
BLASS, RICHARD B., East Haven, Conn.
BOGOT, ALEX., New York, N. Y.
BOLAND, JOHN R., Los Angeles, Calif.
BRAGG, SIDNEY J., Allentown, Pa.
CARR, ROBT. A., Chicago, Ill.
COUTURE, JOS. WALTER, Fulton, N. Y.
DAHMS, ALFRED A., Kansas City, Mo.
DASHIELL, J. W., JR., Pittsburgh, Pa.
DUNN, SAML. O., Chicago, Ill.
ERDMAN, FRANCIS H., Ridgewood, N. J.
FEDERICI, FRANK, Trenton, N. J.
FICKES, ALFRED C., Staten Island, N. Y. (Rt)
GOLOM, JOHN P., Bloomfield, N. J.
HANSEN, ELLIS P., Milwaukee, Wis.
HULL, DONALD R., Newport, Del.
JOHNSON, ROBT. H., Schenectady, N. Y.
KEATING, JOHN T., Chicago, Ill.
KISHEL, CHESTER J., Cleveland, Ohio
KOCHA, JAS. R., Hartford, Conn.
KOLZING, HEINZ H., Chicago, Ill.
LAWRENCE, ANDREW, Brooklyn, N. Y.
LAZARUS, MORTON S., Highland Park, N. J.
LONGRE, THOS. B., Beverly Hills, Calif.
MALLAY, PAUL D., Coatesville, Pa. (Rt & T)
McDONALD, JAS. F., Tulsa, Okla.
Mc PHETERS, LINWOOD S., Wellsville, N. Y.
MEYER, CARL W., Baltimore, Md.
MIMS, W. H., Macon, Ga.
MULLEN, JOHN J., Salt Lake City, Utah (Rt)
NICHOLS, HOWARD R., Minneapolis, Minn.
O'GARA, EDW. F., JR., Tiverton, R. I.
OLT, RICHARD G., Dayton, Ohio (Rt & T)
PERRY, GEO. E., New York, N. Y.
PETERSON, WM. J., Caldwell, N. J.
REANEY, ERNEST, Stratford, Conn.
REYNOLDS, ROBT. L., Ridley Park, Pa.
RICHARDS, JAS. V., Chicago, Ill.
ROTHMAN, NATHAN, Brooklyn, N. Y.
SLAWINSKI, MILTON V., Long Island City, N. Y.
STARK, VIRGIL, Forest Hills, N. Y.
STRANG, HAROLD E., Schenectady, N. Y.
STRICKLAND, FRANK H., Kansas City, Mo.
SURVEYER, ARTHUR, Montreal, Que., Canada
TRAINOR, JOSEPH J., Indianapolis, Ind.
UDSTAD, SIGVALD F., Berwick, Pa.
WEBB, THOS. L. B., Compton, Calif.
WHEELER, F. A. (LT. COMDR.), Los Angeles, Calif.
WIENER, PHILIPPE J. (PVT.), Camp Wheeler, Ga.
WILEY, PAUL R., Charleston, S. C.
WRAY, EDW., Evanston, Ill.
ZINK, J. JOS., Washington, D. C.

CHANGE OF GRADING

Transfers to Member

ASHLEY, HENRY C., Watertown, Conn.
CHAPMAN, ROBT. G., Burlington, Vt.
CONSTANCE, JOHN D., Cliffside, N. J.
JAMESON, STANLEY L., Schenectady, N. Y.
KAUFMAN, MILTON, Washington, D. C.
MILLS, BLAKE D., JR., Washington, D. C.
MYLROIE, JOHN E., Seattle, Wash.
WORTH, EUGENE B., Louisville, Ky.

Necrology

THE deaths of the following members have recently been reported to headquarters:

MORTIMER E. COOLEY, August 25, 1944
BARTON CRUIKSHANK, May 2, 1944
BENJAMIN SPENCER GREENFIELD, August 17, 1944
FRANK S. HEBDEN, March 11, 1944
ROBERT L. HIBBARD, April 13, 1944
AGASSIZ TRAVER HUTCHINS, July 21, 1944
HEBER, CLYDE INSLEE, August 1, 1944
JOHN V. MARTENIS, July 14, 1944
HOWARD E. SATTERFIELD, May 27, 1944
DANA W. WILBER, August 9, 1944

A.S.M.E. Transactions for September, 1944

THE September, 1944, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS
- The Bending of the Cylindrically Aeolotropic Plate, by G. F. Carrier
- The Bending of the Clamped Sectorial Plate, by G. F. Carrier
- Strengthening of Circular Holes in Plates Under Edge Loads, by Leon Beskin
- Equivalent Circuits of the Elastic Field, by Gabriel Kron
- Numerical and Network-Analyzer Solution of the Equivalent Circuits for the Elastic Field, by G. K. Carter
- Basic Mechanics of the Metal-Cutting Process, by M. E. Merchant
- Application of the Fourier Method to the Solution of Certain Boundary Problems in the Theory of Elasticity, by Gerald Pickett
- Analysis of the Valverde Thermostat, by A. M. Wahl

DISCUSSION
- On previously published papers by E. A. Davis; A. M. Binnie; and G. Zerkowitz

BOOK REVIEWS